

# *WINNERS IN LIFE'S RACE*

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## *FISHES AND BIRDS*



*ARABELLA B. BUCKLEY*





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# WINNERS IN LIFE'S RACE

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PART I.

FISHES AND BIRDS







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*Frontispiece.* LUMINOUS FISH OF THE DEEP SEA. (For description see p. 47, and List of Illustrations.)

# WINNERS IN LIFE'S RACE

OR THE

## GREAT BACKBONED FAMILY

BY

ARABELLA B. BUCKLEY

AUTHOR OF

'THE FAIRYLAND OF SCIENCE,' 'LIFE AND HER CHILDREN,' ETC.

PART I.

*FISHES AND BIRDS*

WITH NUMEROUS ILLUSTRATIONS

"Thou gavest me wide nature for my kingdom,  
And power to feel it, to enjoy it. Not  
Cold gaze of wonder gav'st thou me alone,  
But even into her bosom's depth to look,  
As it might be the bosom of a friend.  
The grand array of living things thou madest  
To pass before me, mad'st me know my brothers  
In silent bush, in water, and in air."

*Blackie's Translation of Faust.*

LONDON: EDWARD STANFORD

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## P R E F A C E.

ALTHOUGH the present volume, as giving an account of the *vertebrate* animals, is a natural sequel to, and completion of, my former book, *Life and her Children*, which treated of *invertebrates*, yet it is a more independent work, both in plan and execution, than I had at first contemplated.

This arises from the nature of the subject. The structure and habits of the lower forms of life are sufficiently simple to be treated almost without reference to geological history. When, however, I began to sketch out the lives and structure of the vertebrate animals, which are so closely interlinked one with another and yet so sharply separated into groups, I soon found that I must carry my readers into the past in order to give any intelligible account of the present.

I have therefore endeavoured to describe graphically the early history of the backboned animals, so far as it is yet known to us, keeping strictly to such broad facts as ought in these days to be familiar to

every child and ordinarily well-educated person, if they are to have any true conception of Natural History. At the same time I have dwelt as fully as space would allow, upon the lives of such modern animals as best illustrate the present divisions of the vertebrates upon the earth ; my object being rather to follow the tide of life, and sketch in broad outline how structure and habit have gone hand-in-hand in filling every available space with living beings, than to multiply descriptions of the various species. If my younger readers will try and become familiar with the types selected, either alive in zoological gardens or preserved in good museums, they will, I hope, acquire a very fair idea of the main branches of the Backboned Family.\*

In order to treat so vast a subject simply and within narrow limits, it has often been necessary to pass lightly over new and startling facts. I trust, however, it will not be inferred that such passages have been lightly or carelessly written, for in all cases I have sought, and most gratefully acknowledge, the assistance of some of our best authorities ; and I have endeavoured that what little is said upon difficult subjects shall be a true foundation for wider knowledge in the future.

\* Almost every animal mentioned in this book is to be found alive in the London Zoological Gardens, or stuffed in the British Museum.

Among the many friends who have rendered me valuable assistance, I cannot sufficiently express my obligations to Professor W. Kitchen Parker for his unwearying kindness in explaining obscure points of anatomical structure, and to my friends Mr. Alfred R. Wallace, Professor A. C. Haddon of Dublin, and Mr. Garnett of the British Museum, for constant suggestion and encouragement. I am also indebted to Mr. J. P. Anderson of the British Museum for aid in the arrangement of the Index.

The geological restorations given as picture-headings (some of which are here attempted, I believe, for the first time) have been most carefully considered, though the exact forms of such strange and extinct animals must necessarily be somewhat conjectural. My thanks are due to the artist, Mr. Carreras, jun., for the patience and care with which he has followed my instructions regarding them, and also to Mr. Smit for his masterly execution of the frontispiece.\*

I have been asked why, in this and the former work, I have not given genealogical tables to help the reader to follow the relations of the various groups. My reason is, that it is impossible to con-

\* The Figures in the text, which, with exception of about twenty, have all been drawn expressly for this book, are the work of the above-mentioned artists, together with Mr. Coombe and Miss Suft.



struct tables of this kind without giving a false idea of the fixity of natural divisions and of the extent of our knowledge. To men of science, who know how provisional such tables are, they have a certain value, but they would be positively harmful in a work of this kind, which will have fully accomplished its purpose if it only awakens in young minds a sense of the wonderful interweaving of life upon the earth, and a desire to trace out the ever-continuous action of the great Creator in the development of living beings.

ARABELLA B. BUCKLEY.

LONDON, *September* 1882.

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## CHAPTER I.

### THE THRESHOLD OF BACKBONED LIFE.

LIFE, life, everywhere life! This was the cry with which we began our history of the lowest forms of Life's children, and although we did not then pass on to the higher animals, is it not true that before we reached the end we were overwhelmed with the



innumerable forms of living beings? The microscopic lime and flint builders, the spreading sponges, the hydras, anemones, corals, and jelly-fish filled the waters; the star-fish, sea-urchins, crabs, and lobsters crowded the shores; the oysters, whelks, andperiwinkles, with their hundreds of companions, struggled for their existence between the tides; while in the open sea thousands of crustaceans and molluscs, with cuttle-fish and terribly-armed calamaries, roamed in search of food. Upon the land the snails and slugs devoured the green foliage, while the vast army of insects filled every nook and cranny in the water, on the land, or in the air. Yes! even among these lower forms we found creatures enough to stock the world over and over again with abundant life, so that even if the octopus had remained the monarch of the sea, and the tiny ant the most intelligent ruler on the land, there would have been no barren space, no uninhabited tracts, except those burning deserts and frozen peaks where life can scarcely exist.

Yet though the world might have been full of these creatures, they would not have been able to make the fullest use of it, for all animal life would have been comparatively insignificant and feeble, each creature moving within a very narrow range, and having but small powers of enjoyment or activity. With the exception of the insects, by far the greater number would, during their whole lives, never wander more than a few yards from one spot, while, though the locust and the butterfly make long journeys, yet the bees and beetles, dragon-flies and ants, would not cross many miles of ground in several generations.

What a curious world that would have been in which the stag-beetle and the atlas-moth could boast of being the largest land animals, except where perhaps some monster land snail might bear them company ; while cuttle-fish and calamaries would have been the rulers of the sea, and the crabs and lobsters of the shores ! A strangely silent world too. The grass-hopper's chirp as he rubbed his wings together, the hum of the bee, the click of the sharp jaws of the grub of the stag-beetle, eating away the trunk of some old oak tree, would have been among the loudest sounds to be heard ; and though there would have been plenty of marvellous beauty among the metallic-winged beetles, the butterflies, and the delicate forms of the sea, yet amid all this lovely life we should seek in vain for any intelligent faces,—for what expression could there be in the fixed and many-windowed eye of the ant or beetle, or in the stony face of the crab ?

These lower forms, however, were not destined to have all the world to themselves, for in ages, so long ago that we cannot reckon them, another division of Life's children had begun to exist which possessed advantages giving it the power to press forward far beyond the star-fish, the octopus, or the insect. This was the Backboned division, to which belong the fish of our seas and rivers ; the frogs and toads, snakes, lizards, crocodiles, and tortoises ; the birds of all kinds and sizes ; the kangaroos ; the rats, pigs, elephants, lions, whales, seals, and monkeys.

Is it possible, then, that all these widely different creatures, which are fitted to live not only in all parts of the land, but also in the air above, and the seas and rivers below, and which are, in fact, all those

popularly known as "animals," only form one division out of seven in the real animal kingdom?

Can it be true that while the chalk-builders have one division all to themselves, the sponges forming a transition group, the lasso-throwers another division, the prickly-skinned animals a third, the mollusca a fourth, the worms a fifth, and the insects a sixth, yet the innumerable kinds of birds and beasts, reptiles and fishes, are all sufficiently alike to be included in one single division—the seventh? It seems at first as if this arrangement must be unequal and unnatural; but let us go back for a moment to the beginning, and we shall see that it is not only true, but that quite a new interest attaches to the higher animals when we learn how wonderfully life has built up so many different forms upon one simple plan.

Starting, then, with the first glimmerings of life, we find the minute lime and flint builders, without any parts, making the utmost of their little lives, filling the depths of the sea, and wandering in pools and puddles on the land; acting, in fact, as scavengers for such matter as is left them by other animals. But here their power ends; to take a higher stand in life a more complicated creature is needed, and the sponge-animal, with its two kinds of cells and its numerous eggs, is the next step leading on to the curious division of lasso-throwers. These, in their turn, do their utmost to spread and vary in a hundred different ways. Possessed of a good stomach, of nerves, muscles, powerful weapons, and means for producing eggs and young ones, they fill the waters as hydras, sea-firs, jelly-fish, anemones, and corals. But here they too find their limit, and, without advancing



any farther, continue to flourish in their lowly fashion. Meanwhile the tide of life is flowing on in two other channels, striving ever onwards and upwards. On the one hand, the walking star-fish and sea-urchin push forward into active life under the sea, forming, with their relations, a strange and motley group, but one which could scarcely be moulded into higher and more intelligent beings. On the other hand, the oyster and his comrades, with their curious mantle-working secret protect their soft body within by a shelly covering, and by degrees we arrive at the large army of mollusca, headed by the intelligent cuttle-fish. And here this division too ceases to advance. The soft body in its shelly home does not lend itself to wide and great changes, and it was left for other channels to carry farther the swelling tide of life. These take their rise in the lowly, insignificant division of the worms, which may, perhaps, have had something to do with the earliest forms even of the star-fish and mollusca, but which soon shot upwards, on the one hand along a line of its own, while, on the other, we have seen\* how, in its many-ringed segments, each bearing its leg-like bristles and its line of nerve-telegraph, the worm foreshadowed the insects and crustacea, or the *jointed-footed* animals of sea and land, forming the sixth division.

Here surely at last we must have reached animals which will answer any purposes life can wish to fulfil. We find among them numberless different forms, spreading far and wide through the water and over the land, and it would seem as if the sturdy crab and

\* *Life and her Children*, p. 135.

fighting lobster need fear no rival in the sea, while the intelligent bee and ant were equal to any emergency on dry ground. But here the tide of life met with another check. It must be remembered that the jointed-footed animals, whether belonging to land or water, carry their solid part or skeleton *outside* them ; their body itself is soft, and cased in armour which has to be cast off and formed afresh from time to time as they grow. For this reason they are like men in armour, heavily weighted as soon as they grow to any size, while the body within cannot become so firmly and well knit together as if all the parts, hard and soft, were able to grow and enlarge in common. And so we find that large-sized armour-covered animals, such as gigantic crabs and lobsters, are lumbering unwieldy creatures, in spite of their strength, while the nimble intelligent insects, such as the ant and bee, are comparatively small and delicate.

It would be curious to try and guess what might have happened if the ant could have grown as large as man, and built houses and cities, and wandered over wide spaces instead of being restricted to her ant-hills for a home, and few acres for her kingdom ; but she too has found the limit of her powers in the impossibility of becoming a large and powerful creature. Thus it remained for Life to find yet another channel to reach its highest point, by devising a plan of structure in which the solid skeleton should be—not a burden for the soft body to carry, as in the sea-urchins, snails, insects, and crabs—but an actual support to the whole creature, growing with it and forming a framework for all its different parts.

This plan is that of the backboned animals. They alone, of all Life's children, have a *skeleton within their bodies embedded in the muscular flesh, and formed, not of mere hardened, dead matter, but of bones which have blood-vessels and nerves running through them, so that they grow as the body grows, and strengthen with its strength.* This is a very different thing from a mere outer casing round a soft body, for it is clear that an animal with a living growing skeleton can go on increasing in size and strength, and its framework will grow *with* the limbs in any direction most useful to it.

Here, then, we have one of the secrets why the backboned animals have been able to press forward and vary in so many different ways; and especially useful to them has been that gristly cord stretching along the back, which by degrees has become hardened and jointed, so as to form that wonderful piece of mechanism, the *backbone*.

Look at any active fish darting through the water by sharp strokes of its tail,—watch the curved form of a snake as it glides through the grass, or the graceful swan bending his neck as he sails over the lake,—and you will see how easily and smoothly the joints of the backbone must move one upon the other. Then turn to the stag, and note how jauntily he carries his heavy antlers; look at the powerful frame of the lion, watch an antelope leap, or a tiger bound against the bars of his cage, and you will acknowledge how powerful this bony column must be which forms the chief support of the body, and carries those massive heads and those strong and lusty limbs.



Nor is it only by its flexibility and strength that this jointed column is such an advantage to its possessors ; the backbone has a special part to play as the protector of a most valuable and delicate part of the body. We have already learnt in *Life and her Children* to understand the importance of the nerve-telegraph to animals in the struggle for life. We found its feeble beginnings in the jelly-fish and the star-fish ; we saw it spreading out over the body of the snail ; we traced it forming a line of knots in the worm, with head-stations round the neck, which became more and more powerful in the intelligent insects. But in all these creatures the stations of nerve-matter from which the nerves run out into the body are merely embedded in the soft flesh, and have no special protection, with the exception of a gristly covering in the cuttle-fish. We ourselves, and other backboned animals, have unprotected nerve-stations like these in the throat, the stomach, and the heart, and cavity of the body. But we have something else besides, for very early in the history of the backboned animals the gristly cord along the back began to form a protecting sheath round the line of nerve-stations stretching from the head to the tail, so that this special nerve-telegraph was safely shut in and protected all along its course.

A careful examination of the backbone of any fish, after the flesh has been cleared off, will show that on the top of each joint (or *vertebra*) of the backbone is a ring or arch of bone ; and when all the joints are fastened together, these rings form a hollow tube or canal, in which lies that long line of nervous matter called the *spinal cord*,

which thus passes, well protected, all along the body, till, when it reaches the head, it becomes a large mass shut safely in a strong box, the skull, where it forms the brain.

Here, then, besides the unprotected nerve-stations, we have a much more perfect nerve-battery, the spinal cord, carried in a special sheath formed of the arches of the backbone, which is at once strong and yielding, so that the delicate telegraph is safe from all ordinary danger. Now when we remember how important the nerves are,—how they are the very machinery by which intelligence works, so that without them the eye could not see, the ear hear, nor the animal have any knowledge of what is going on around it,—we see at once that here was an additional power which might be most valuable to the backboned division. And so it has proved, for slowly but surely through the different classes of fish, amphibia (frogs and newts), reptiles, birds, and mammalia, this cord, especially that larger portion of it forming the brain, has been increasing in vigour, strength, and activity, till it has become the wonderful instrument of thought in man himself.

We see, then, that our interest in the backboned or *vertebrate* animals will be of a different kind from that which we found in the boneless or *invertebrate* ones. There we watched Life trying different plans, each successful in its way, but none broad enough or pliable enough to produce animals fitted to take the lead all over the world. Now we are going to trace how, from a more promising starting-point, a number of such different forms as fish, reptile, bird, and four-footed beast, have gradually arisen and

taken possession of the land, the water, and the air, pressing forward in the race for life far beyond all other divisions of animal life.

On the one hand, these forms are all linked together by the fact that they have a backbone protecting a nerve-battery, and that they have never more than two pair of limbs ; while every new discovery shows how closely they are all related to each other. On the other hand, they have made use of this backbone, and the skeleton it carries, in such very different ways that out of the same bones and the same general plan unlike creatures have been built up, such as we should never think of classing together if we did not study their structure.

What the lives of these creatures are, and what they have been in past time, we must now try to understand. And first we shall naturally ask, Where did the backboned animals begin? Where should they begin but in the water, where we found all the other divisions making their first start, where food is so freely brought by passing currents, where movement from place to place is much easier, and where there are no such rapid changes as there are on the land from dry to damp, from heat to cold, or from bright leafy summer, with plenty of food, to cold cheerless winter, when starvation often stares animals in the face?

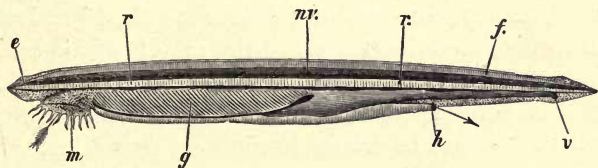
It is not easy to be sure exactly how the backboned animals began, but the best clue we have to the mystery is found in a little half-transparent creature about two inches long, which is still to be found living upon our coast. This small insignifi-



cant animal is called the "Lancelet,"\* because it is shaped something like the head of a lance, and it is in many ways so imperfect that naturalists believe it to be a degraded form, like the acorn-barnacle; that is to say, that it has probably lost some of the parts which its ancestors once possessed. But in any case it is the most simple backboned animal we have, and shows us how the first feeble forms may have lived.

Flitting about in the water near the shore, eating the minute creatures which come in his way, this small fish-like animal is so colourless, and works his

Fig. 1.



The Lancelet, the lowest known fish-like form.

*m*, mouth. *e*, eye-spot. *f*, fin. *r*, rod or notochord, the first faint indication of a backbone. *nw*, nerve cord. *g*, gills. *h*, hole out of which water passes from the gills. *v*, vent for refuse of food.

way down in the sand so fast at the slightest alarm, that few people ever see him, and when they do are far more likely to take him, as the naturalist Pallas did, for an imperfect snail than a vertebrate animal. He has no head, and it is only by his open mouth (*m*), surrounded by lashes with which he drives in the microscopic animals, that you can tell where his head ought to be. Two little spots (*e*) above his mouth

\* *Amphioxus lanceolatus* (*amphi* both, *oxus* sharp).

are his feeble eyes, and one little pit (*n*) with a nerve running to it is all he has to smell with. He has no pairs of fins such as we find in most fishes, but only a delicate flap (*f*) on his back and round his tail ; neither has he any true breathing-gills, but he gulps in water at his mouth, and passes it through slits in his throat into a kind of chamber, and from there out at a hole ( $\frac{1}{2}$ ) below. Lastly, he has no true heart, and it is only by the throbbing of the veins themselves that his colourless blood is sent along the bars between the slits, so that it takes up air out of the water as it passes.

But where is his backbone? Truly it is only by courtesy that we can call him a backboned animal, for all he has is a cord of gristle, *rr*, pointed at both ends, which stretches all along the middle of his body above his long narrow stomach, while above this again is another cord containing his nerve-telegraph (*nv*.) All other backboned animals that we know of have brains ; but, as we have seen, he has no head, and his nerve-cord has only a slight bulge just before it comes to a point above his mouth. Now when the higher backboned animals are only just beginning to form out of the egg, their backbone (which afterwards becomes hard and jointed) is just like this gristly rod or *notochord* (*r r*) of the lancelet, with the spinal cord (*nv*) lying above it ; so that this lowest backboned animal lives all his life in that simple state out of which the higher animals very soon grow.

This imperfect little lancelet has a great interest for us, because of his extremely simple structure and the slits in his throat through which he

breathes. You will remember that when we spoke of the elastic-ringed animals in *Life and her Children*, we found that the free worms were very active sensitive creatures, whose bodies were made up of segments, each with a double pair of appendages; the whole being strung together, as it were, upon a feeding tube and a line of nerve-telegraph, but without any backbone. Now among these worms we find many curious varieties; some have the nerve-lines at the sides instead of below, and one sea-worm, instead of breathing by outside gills like the others, has slits in its throat through which the water can pass, and so its blood is purified.

You may ask, What this has to do with backboned animals? Nothing directly, but these odd worms are like fingerposts in a deserted and grass-grown country, showing where roads may once have been. The lancelet, like the worm, has a line of nerve-telegraph and a feeding-tube, only with him the nerve-telegraph lies above instead of below. He has also slits in his throat for breathing, only they are covered by a pouch. Thus he is so different from the worms that we cannot call them relations; but at the same time he is in many ways so like, that we ask ourselves whether his ancestors and those of the worms may not have been relations.

But you will say he is quite different in having a gristly cord. True—but we shall find that even this does not give us a sharp line of division. By looking carefully upon the seaweed and rocks just beyond low tide, we may often find some curious small creatures upon them, called Sea-Squirts or Ascidians



(B, Fig. 2).<sup>\*</sup> These creatures are shaped very like double-necked bottles, and they stand fixed to the rock with their necks stretching up into the water.

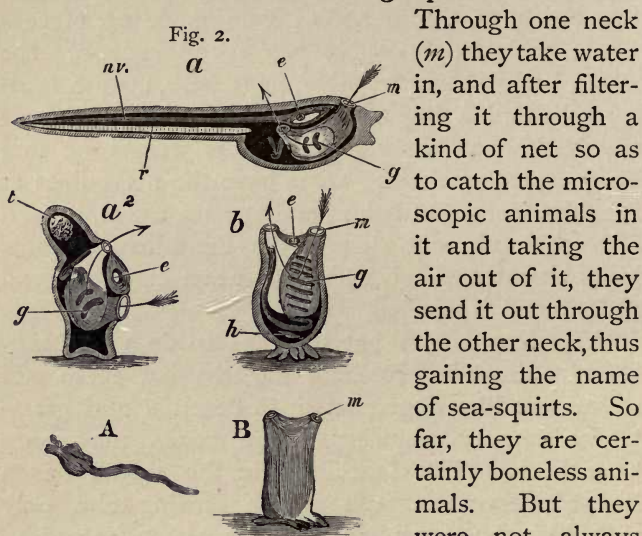


Diagram of the growth of a Sea-Squirt or Ascidian.

A a, Young free swimming stage. a<sup>2</sup>, Intermediate stage when first settling down. B b, Full-grown Sea-Squirt.

m, mouth; e, hollow brain with eye; g, gill slits; h, heart; r, rod of gristle in free swimming form; nv, nerve cord in same; t, tail in process of absorption in intermediate form.

in the tail was a gristly cord (r), with a nerve cord (nv) above it, like those we find in the lancelet. For this reason we

<sup>\*</sup> For this drawing, and also those of Figures 1 and 4, I am indebted to Professor A. C. Haddon; the larval form A is the young of *Clavelina*, found at Torquay.

were obliged to pass them by among the lower forms of life, because, having this cord (*r*), they did not truly belong to the animals without backbones; and yet now we can scarcely admit them here, because when they are grown up they are not backboned animals. They belong, in fact, to a kind of "No Man's Land," behaving in many ways like the lancelet when they are young, as if they had once tried to be backboned; and yet they fall back as they grow up into invertebrate animals.

So we begin to see that there may have been a time when backbones had not gained quite a firm footing, and our lancelet, with his friends the sea-squirts, seems to lie very near the threshold of backbone life.

And now that we are once started fairly on our road, let us turn aside before beginning the history of the great fish-world and pay a visit to a little creature whose name, at least, we all know well, and which stands half-way between the lancelet and the true fish. This is the Lamprey, represented by two kinds; the large Sea-Lamprey, caught by the fishermen for bait as it wanders up the rivers to lay its eggs, and the true River-Lamprey or Lampern, which rarely visits the sea.

What country boy is there who has not hunted in the mud of the rivers or streams for these bright-eyed eel-like fish, with no fins, and a fringe on back and tail? If you feel about for them in the mud they will often come up clinging to your hand with their round sucker-mouth, while the water trickles out of the seven little holes on each side of their heads. The small river-lampreys do not hurt in the least as they cling, though the inside of their

mouth is filled with small horny teeth. But the larger sea-lamprey uses these teeth as sharp weapons, scraping off the flesh of fish for food as he clings to them.

These Lampreys, together with some strange creatures, the "Hags" or "Borers,"\* belong to quite a peculiar family, called the Round-mouthed fishes,†

Fig. 3.



Figure of a full-grown Lamprey‡ and of the young Lamprey, formerly called Ammocoetes.

*Showing the seven holes through which it takes in water to breathe.*

and, though they stand much higher in the world than the lancelet, yet they are very different from true fish. Like the lancelet they have only a gristly

\* Myxine.

† Cyclostomata (*cyclos*, circle ; *stoma*, mouth).

‡ Petromyzon (*petra*, stone ; *myzo*, to suck).



cord for a backbone, but this cord has begun to form arches over the nerve battery, and it swells out at the end into a gristly skull covering a true brain. They have clear bright eyes too, and ears, which if not very sharp, are at least such as they can hear with; they have only one nostril, and their mouth is both curious and useful. When it is shut it looks like a straight slit, but when it is open it forms a round sucker with a border of gristle, and this sucker clings firmly to anything against which it is pressed, so that a stone weighing twelve pounds has been lifted by taking a lamprey by the tail. Inside the mouth the palate and tongue are covered with small horny teeth, and these are the lamprey's weapons.

Salmon have been caught in the rivers with lampreys hanging to them, and where the mouth has been the salmon's flesh is rasped away, though he does not seem much to mind it.

Lastly, the lamprey has a peculiar way of breathing. He has seven little holes on each side of his head, reminding us of the slits in the worm's throat and those hidden under the skin of the lancelet, and behind these holes are seven little pouches lined with blood-vessels, which take up air out of the water. These pouches are all separate, but they open by one tube into his throat. When the lamprey is swimming about it is possible that he may gulp water in at his mouth and send it out at the slits. But when he is clinging to anything he certainly sends water both in and out at the slits, so that he can still breathe, though his mouth is otherwise occupied.

And now, what is the history of his life? For  
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three years he lives as a stupid little creature, with a toothless mouth surrounded by feelers, and tiny eyes covered over with skin, and he is so unlike a lamprey that for a long time naturalists thought he was a different animal and called him *Ammocætes*. But at the end of the three years he changes his shape, and then he is as bright and intelligent as he was dull and heavy before. His one thought is to find a mate and help her to cover up her eggs. To do this a number of lampreys find their way up the river and set to work. Sometimes one pair go alone, sometimes several together, and they twirl round and round so as to make a hole in the sand, lifting even heavy stones out with their mouths if they come in the way. Then they shed the spawn into the hole, where it is soon covered with sand and mud, to lie till it is safely hatched, and when this is done the marine lampreys swim out to sea to feed on the numberless small creatures in it, or to fasten upon some unfortunate fish.

But there are round-mouthed fishes even more greedy than these. It is not only among the lower forms of life that some creatures, such as worms, which are driven from the outer world, find a refuge inside other animals. But here again we meet with the same thing, for those relations of the lampreys, the hags or borers, which we mentioned above, use their sharp teeth to bore their way into other fish so as to feed upon them. These greedy little creatures actually drill holes in the flesh of the cod or haddock and other fish, and eat out the inside of their bodies, so that a haddock has been found with nothing but the skin and skeleton remaining while six fat hags lay comfortably inside.

So the round-mouthed fishes, feeble though they are, hold their own in the world. How long ago it is since they first began the battle of life we shall probably never know for certain ; but if some little horny teeth \* found in very ancient rocks belong to their ancestors, they were most likely among the first backboned animals on our globe. At any rate they are very interesting to us now, for they have wandered far away from the true fishes, and give us a glimpse of some of the strange by-paths which the backboned animals have followed in order to win for themselves a place in the race for life.

\* Called *conodonts*, and found in Lower Silurian rocks earlier than any bones of true fish.





## CHAPTER II.

HOW THE QUAIN'T OLD FISHES OF ANCIENT TIMES  
HAVE LIVED ON INTO OUR DAY.

WHO is there among my readers who wishes to understand the pleasures, the difficulties, and the secrets of fish life? Whoever he may be he must not be content with merely looking down into the

NOTE.—For description of the Picture-Headings see the Table of Contents.

water, as one peeps into a looking-glass, or he may, perchance, only see there the reflection of his own thoughts and ideas, and learn very little of how the fishes really feel and live. No! if we want really to understand fish-life we must forget for a time that we are land and air-breathing animals, and must plunge in imagination into the cool river or the open sea, and wander about as if the water were our true home. For the fish know no more about our land-world than we do about their beautiful ocean-home. To them the water is the beginning and end of everything, and if they come to the top every now and then for a short air-bath they return very quickly for fear of being suffocated. Their great kingdom is the sea—the deep-sea, where strange phosphorescent fish live, lying in the dark mysterious valleys where even sharks and sword-fish rarely venture;—the open sea, where they roam over wide plains when the ocean-bottom makes a fine feeding-ground, or where they thread their way through forests of seaweed, while others swim nearer the surface and come up to bask in the sun or rest on a bank of floating weed;—and the shallow sea, where they come to lay their eggs and bring up their young ones, and out of which many of them venture up the mouths of rivers, while others have learnt to remain in them and make the fresh water their home.

The tender little minnows that bask in the sunny shallows of the river have never even seen the sea, their ancestors left it so long long ago; yet to them, too, water is life and breath and everything. The green meadow through which the river flows is just the border of their world and nothing more,

and the air is boundless space, which they never visit except for a moment to snap at a tiny fly, or when they jump up to escape the jaws of some bigger fish. Every one knows the minnow, and we cannot do better than take him as our type of a fish in order to understand how they live and move and breathe. Go and lie down quietly some day by the side of the clear pebbly shallows of some swiftly-flowing river where these delicate little fish are to be seen; but keep very still, for the slightest movement is instantly detected. There they lie.

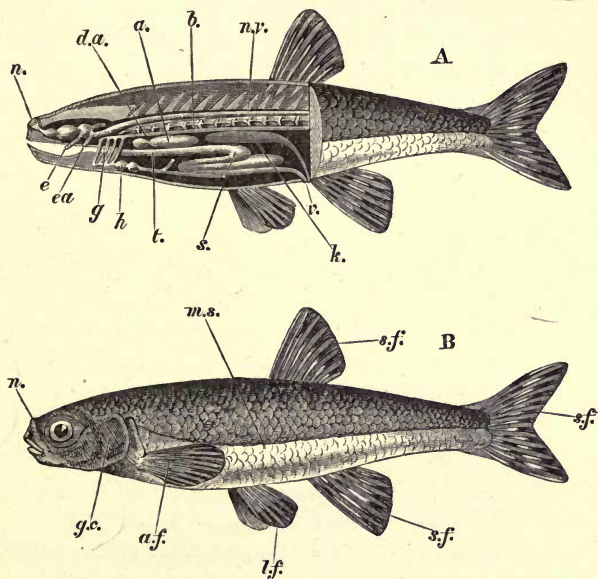
“ Staying their wavy bodies 'gainst the streams  
To taste the luxury of sunny beams  
Tempered with coolness. How they ever wrestle  
With their own sweet delight, and ever nestle  
Their silver bellies on the pebbly sand !  
If you but scantily hold out the hand,  
That very instant not one will remain ;  
But turn your eye and they are there again.”

If you can be motionless and not frighten them you may see a good deal, for while some are dashing to and fro, others, with just a lazy wave of the tail and the tiny fins, will loiter along the sides of the stream, where you may examine their half-transparent bodies. Look first at one of the larger ones, whose parts are easily seen, and notice how every moment he gulps with his mouth, while at the same time a little scaly cover (*g c*, B, Fig. 4) on each side of the head, just behind the eye, opens and closes, showing a red streak within. This is how he breathes. He takes in water at his mouth, and instead of swallowing it passes it through some bony toothed slits (*g*, A Fig. 4) in his throat into a little chamber under that scaly cover; in that chamber, fastened to the bony slits, are a



number of folds of flesh full of blood-vessels, which take up the air out of the water ; and when this is done he closes the toothed slits and so forces the bad water out from under the scaly cover back into the river again. It is the little heart (*h*), lying just behind

Fig. 4.



The structure of the Minnow and the living fish.

A *n*, nose-pit ; *e*, eye-nerve ; *ea*, ear-nerve ; *g*, gills ; *h*, heart ; *t*, food-tube ; *s*, stomach ; *k*, kidney ; *v*, vent ; *da*, dorsal-artery. *a*, air-bladder ; *b*, backbone ; *nv*, nerve cord or spinal cord.

B *n*, nose ; *gc*, gill cover ; *af*, arm-fin ; *lf*, leg-fins ; *sf*, single fins ; *ms*, mucous scales.

the gills, which pumps the blood into the channels in those red folds, and as it keeps sending more and more, that which is freshened is forced on and flows

through the rest of the body. It goes on its way slowly, because a fish's heart has only two chambers instead of four as we have, and these are both employed in pumping the blood *into* the gills, so that for the rest of the journey through the body it has no further help. For this reason, and also because taking up air out of the water is a slow matter, fish are *cold-blooded* animals, not much warmer than the water in which they are.

But while our minnow breathes he also swims. He is hardly still for a moment, even though he may give only the tiniest wave with his tail and fins, and he slips through the water with great ease, because his body is narrow and tapers more or less at both ends like a boat. At times, too, if he is frightened, he bounds with one lash of his tail right across the river ; and if you look at one of the small transparent minnows you will see that he has power to do this because his real body, composed of his head and gills, heart and stomach, ends at half his length (see Fig. 4, A), and all the rest is tail, made of backbone and strong muscles, with which he can strike firmly. This is one great secret of fish strength, that nearly one half of their body is an implement for driving them through the water and guiding them on their way. Still although the tail is his chief propeller, our minnow could not keep his balance at all if it were not for his arm and leg fins. You will notice that it is the pair of front fins (*af*) which move most, while the under ones (*lf*) are pressed together and almost still. Besides these two pairs he has three single fins (*sf*), one under his body, one large V-shaped one at the end of his tail, and another single one upon his back.

All these different fins help to guide him on his way ; but while the single ones are fish-fringes, as it were, like the fringe round the lancelet's body, only split into several parts, the two pair under his body are real limbs, answering to the two pair of limbs we find in all backboned animals, whether they are all four fins, or all four legs, or wings and legs, or arms and legs.

These paired wings are most important to the minnow, for, if his arm-fins were cut off, his head would go down at once, or, if one of them was gone he would fall on one side, while, if he had lost his fins altogether, he would float upside down as a dead fish does, for his back is the heaviest part of his body. It is worth while to watch how cannily he uses them. If you cannot see him in the stream you can do so quite well in a little glass bowl, as I have him before me now. If he wants to go to the left he strikes to the right with his tail and moves his right arm-fin, closing down the left, or if he wants to go to the right he does just the opposite ; though often it is enough to strike with his tail and single fin below, and then he uses both the front fins at once to press forward.

But how does he manage to float so quietly in the water, almost without moving his fins? If your minnow is young and transparent you will be able to answer this question by looking at his body just under his backbone, and between it and his stomach. There you will see a long, narrow, silvery tube (*a*, Fig. 4) drawn together in the middle so that the front half near his eyes looks like a large globule of quicksilver, and the hinder half like a tiny silver sausage. This silvery tube is a bladder full of



gas, chiefly nitrogen, and is called the *air-bladder*. Its use has long been a great puzzle to naturalists, and even now there is much to be learnt about it. But one thing is certain, and that is, that fish such as sharks, rays, and soles, which have no air-bladders, are always heavier than the water, and must make a swimming effort to prevent sinking. Fish, on the contrary, which have air-bladders, can always find some one depth in the water at which they can remain without falling or rising, and we shall see later on that this has a great deal to do with the different depths at which certain fish live. Our minnow floats naturally not far from the top, and, even if he were forced to live farther down, the gas in his bladder would accommodate itself after a few hours if the change was not too great, and he would float comfortably again.

And now the question remains, What intelligence has the minnow to guide him in all these movements? If you will keep minnows and feed them yourself every day you will soon find out that they see, smell, and feel very quickly, though their hearing and taste are not so acute. They are cunning enough too, and will often steal a march upon heavier and slower fish, snatching delicate morsels from under their very noses. For our little minnow can boast of a real brain, though it is a small one in comparison with his size. All along, above his delicate backbone, the thread of nerve telegraph (*nn*, Fig. p. 23) runs under protecting bony arches, and sends out nerves on all sides to the body and fins; and when it reaches the head it swells out, under a bony covering, into a small brain, sending out two nerves to the ears (*ea*), in front of which is a second part, with two

nerve-stations (*e*) for the eyes, and beyond this a third part, with two more for the nostrils, besides others which go to the face. Look on the top of a minnow's head and you will see two little raised bumps (*n*). These are its nostrils, but remember *they have nothing to do with breathing*; they have not even any connection with the mouth, but are simply little covered cups, each with two openings for water to flow in and out, and they are lined with nerves, which, tickled by good or bad scents in the water, carry to the brain a warning, or a promise of good things.

Such, then, is our little minnow, and the different parts of his body are supported by a slender bony-jointed backbone, with ribs growing from it, supporting a strong mass of flesh on his sides. He is a delicate tender creature, but is protected and buoyed up by the water, out of which he never attempts to go. The thin, rounded, transparent scales which cover his body, growing out of little pockets in his skin, just like our nails on the tips of our fingers, protect this skin from the water and from rough treatment; while they themselves are kept soft by a slimy fluid which oozes out from under them, and especially through the dark line of larger scales (*ms.* Fig. p. 23) running along his body.

Now the minnow is a bony fish, and from it we can learn very fairly what bony or modern fishes are like. But these fish were not the founders of the race; long before they existed there was another very ancient group of fishes in the world, which were in many ways more like the lancelet and the lamprey; and to find such descendants of this ancient group as are now living we must leave the river and find our way into the open sea.

If we do this, we shall travel not many miles from the shore in summer, wending our way through shrimps and lobsters, gurnards, cod-fish, soles, and turbot, before we may chance to come across a great Blue shark, with his slaty-coloured back and fins, swimming heavily but strongly through the water, and turning sharply from time to time to seize a passing fish, his white belly gleaming like a flash of light as it comes uppermost, and then disappearing again in the dark water.

“ His jaws horrific, armed with threefold fate,  
Here dwells the direful shark.”

Or if this formidable monster does not happen to be in the neighbourhood another kind, the Dogfish, may cross our path, perhaps the Smooth hound, crushing the crabs and lobsters in his tooth-lined mouth, or the Rough hound fastening her purse-like egg to the sea-weed by its long string-like tendrils ; or, farther out still, we may perhaps see the Thresher shark lashing the water with his long pointed tail, to drive the frightened fish within his reach ; or, if we were off the west coast of Ireland, the huge but harmless Basking shark might be floating calmly by in the warm sunshine. For sharks travel all over the ocean, and though they prefer the warm seas, where they sometimes reach a size of forty feet long and more, yet many of the smaller kinds visit our coasts in summer.

Now, at first sight we might imagine that these huge monsters, the terrible tyrants of the sea, must be the last and most finished production of fish-life ; but if we look a little closer we shall be undeceived. Examine a shark in any good museum, and you cannot fail to be struck with his strange form.



Look first at his tub-like body, so different from the narrow wedge-shape of the minnow, the her-  
ring, or the salmon. Then observe his skin, which is either tough, more like that of other animals, or thickly covered with short blunt teeth, which sometimes, especially in front of the fins, become long pointed spines. There is no trace of fish-scales here. Look at his mouth opening under his point-

Fig. 5.



The Blue Shark \* (from Brehm).

To show the five slits in the neck, the uneven tail, and the mouth opening under the pointed snout.

\* *Carcharias glaucus*.

ed snout, and you will see that as the skin turns over the lips these blunt teeth line his mouth, so that he has several rows fit for biting, and they are sometimes so formidable that they can cut a man in two at one snap. Then look more especially at the sides of his throat, and there you will see on each side from five to seven slits, reminding you at once of the slits of the lamprey, though they are long instead of round. For the shark has never arrived at having true gills under a horny cover like the minnow, but still breathes by pouches and slits somewhat after the way of the lowly round-mouthed fishes. Lastly, observe his curious tail. In nearly all living fish the tail is even\* or V-shaped, but in the sharks the top point is usually longer than the lower one,† and in some, such as the Thresher, it is very remarkably so.

This uneven tail is the badge of a very ancient race; out of the shark family we scarcely find it anywhere now except among the sturgeons, who, we shall see, are old-fashioned too.

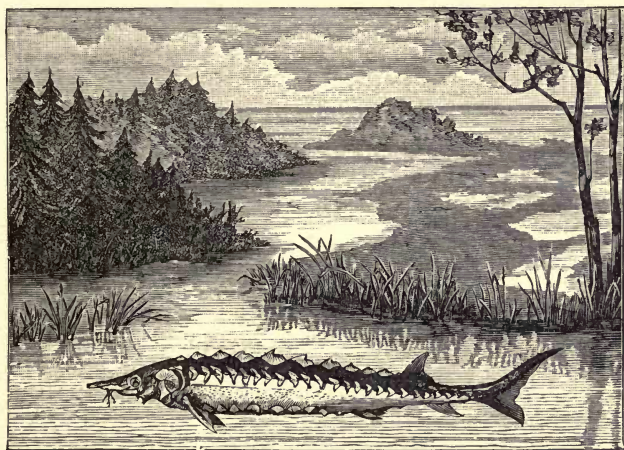
And now when we inquire into the growth of the shark and the kind of backbone he has, we find that he has still more links with the lower fish-like animals. For when he is young he has nothing but a rod of gristle or cartilage running between the long narrow feeding-tube and the spinal cord; but this rod is flattened in front, and as the young shark grows up the flat part enlarges so as to form a boat-like box—the skull, round the swollen end of the nerve telegraph—the brain. Meanwhile the rod becomes divided into rings, and from each ring an arch of

\* Homocercal.

† Heterocercal.

gristle growing upwards surrounds the nerve cord so as to protect it from injury, and the whole skeleton becomes firm and strong. But though the shark is one of the strongest of sea-animals *he never loses this gristly state of his backbone or his skeleton*; however much he may strengthen it by hard matter it never

Fig. 6.



The Sturgeon\* entering a Russian river.

becomes true bone, but remains quite distinct from the skeleton of the bony or osseous fish.

We see, then, that there is a race of gristly or *cartilaginous* fishes, which, though they have grown strong and powerful, still hold to many primitive habits in forming both their body and skeleton. Nor do the sharks stand alone, for the large sturgeons, which live partly in the sea and partly in fresh water,

\* *Acipenser sturio*.



crowding up the rivers of Russia and America to grope in the river mud for food, and to lay their millions of eggs, are also remnants of the ancient type. It is true that with them the slits in the neck are covered by a horny flap like the bony fish, and like them too they have an air-bladder under the backbone.\* But they too have a gristly skeleton, and the gristly rod more or less hardened runs right along their back. In other respects they are perhaps even more peculiar than the sharks; for the sturgeon's head is covered with hard bony shields, and five rows of bony bucklers are arranged along his body. We seem almost to have got back among the armour-covered animals as we look at his shiny plates, reminding us that with a mere gristly skeleton within, it

Fig. 7.



The Sturgeon's head seen from below, showing the tube-like mouth and the four barbels or feelers.

may have been wise for the early types of fish to wear some outward protection. His snout is long and pointed, with four delicate feelers hanging down from it, and his mouth, which is quite under his head, is a soft open tube without teeth, which he can draw up or push out to suck up fish or any animal matter he finds in the mud.

Clearly the sturgeon is an old-fashioned fellow, as you may see for yourself, when specimens caught at the mouths of our rivers are shown in the fishmongers' shops. I have often wondered, when standing looking at him and at the sharks in the British Museum, whether the people who stroll by

\* Isinglass is made from the covering of this air-bladder.

have any idea what a strange history these quaint old fishes have, or how they stand there among the scaly and bony fishes lying in the cases around, just as an Egyptian and a Chinaman might stand in an English crowd, descendants of old and noble races of long long ago, whose first ancestors have been lost in the dim darkness of ages, whose day of strength and glory was at a time when the modern races had not yet begun to be, and whose representatives now live in a world which has almost forgotten them.

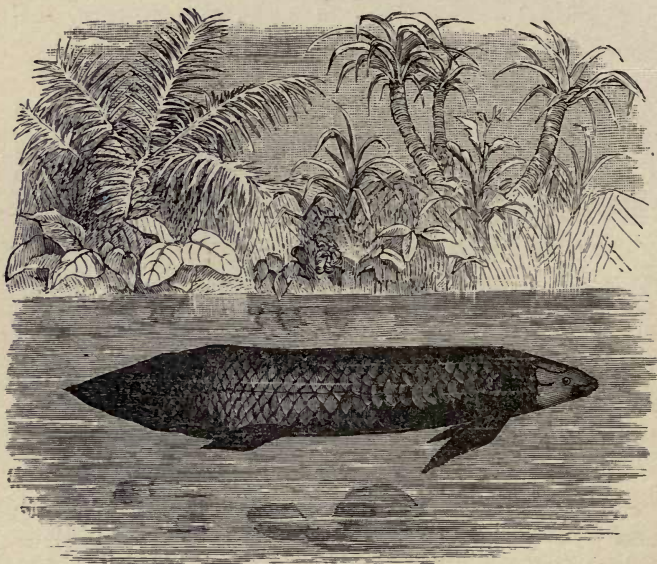
In the silent depths of the large lakes of North America there is a fish called the Bony pike,\* a huge fellow often six feet long, with a long beak-shaped mouth, which he snaps as he goes, devouring everything that comes in his way. This fish has his body covered with lozenge-shaped, bony, enamelled scales, like the fish of long ago, and so too has the strange Bichir,† which wanders above the cataracts of the Nile, with its row of eight to eighteen fins raised upon its back like tiny sails. Then again there are the curious calf-fish of North America,‡ of the Amazons,§ of the Nile,|| and of the rivers of Queensland in Australia.¶ These all have gristly skeletons, and together with the sharks and sturgeons make up all that remains of those strange shadows of the past moving among the bony fishes of to-day.

The mud-fishes are indeed the most curious of all, for they breathe both water and air, and in the Nile and Gambia often coil themselves round in the mud when the water goes down, and, lining their bed with slime, sleep comfortably till the

\* *Lepidosteus*.    † *Polypterus*.    ‡ *Amia*.    § *Lepidosiren*.  
                     || *Protopterus*.                      ¶ *Ceratodus*.

rains refill the pools with water.\* The fact is they have two quite separate ways of breathing. They have gills with which they can take air out of the water like other fish, and these they always use when they can. But they have a tube in their throat leading into the air-bladder lying under their backbone, and through this

Fig. 8.



The *Ceratodus* of Queensland, an air-breathing and water-breathing mud-fish of the ancient type, with paddle-fins.

they can breathe in air when they cannot get it from the water. In *Amia* especially, which is a true enamel-scaled fish, this air-bladder is divided into numerous cells, and it breathes with it just as with a lung.

It was in the year 1870 that the *Ceratodus*, or

\* These fish, coiled round, may be seen in the British Museum.



the "Barramunda," as the Australian natives call him, was discovered in the rivers of Queensland ; and since then he has become very famous, for, more than any of the others, he is like the fishes of long ago. He is a lumpy fish, sometimes as much as six feet long, with a gristly cord for a backbone. His body is covered with large rounded scales, and he has a broad fringe round his pointed tail. His fins are more like paddles than fish fins, having several joints, and he uses them, together with his fringed tail, to flap along in the water, or even to wander over the reedy flats at night, chewing the weeds with his broad ridged teeth. And as he flaps along, from time to time, when the water is too muddy for his liking, he comes up to the top, and with a great gulp swallows air into the air-chamber. But before he can do this he must send out the bad air within, and in doing so he gives a grunt which is often heard far away at night in those still Australian wilds. He need not come up for air-breathing, however, if the water is pure, for, strange to say, the whole course of his blood can be altered to suit his wants. When he can get clear water to breathe through his gills the blood flows to them to be freshened, and his air-bladder simply takes in gas from the body as it does in other fishes, and wants feeding with good blood. But when he comes up to breathe then the blood is carried the other way, and comes to the air-bladder to be freshened.

And now if we want to read the history of all these strange forms, you must let me take you by the hand and lead you in imagination back, back through millions of years, to a time so long ago that we cannot even count the ages between. As we

recede from our own day we shall leave behind us all the kinds of plants and animals we now know so well, and meet with strange kinds only bearing a general resemblance to them. After a long journey of thousands and thousands of years, in which the plants and animals, and even the very shape of the continents and islands, have gone through many changes, we shall get back to the time when the lime-builders were forming thin layers of chalk at the bottom of the sea, which were afterwards to become our enormous chalk hills. Still backwards we must go through all that long period, and then through three others quite as long, with ever-changing scenes of life and climate and geography, till we find ourselves in those grand old forests whose trees and plants we now dig out as coal.

Even then we must not stop to rest, though we are getting back to the dim ages of the world, for the journey is not yet ended. On, on, backwards through countless years, till we lose sight not only of beasts and birds and reptiles, but even of insects and flowering plants, which, at the time we are reaching, had not yet begun to be. At last we lose almost all life upon the land, so far as we can tell, and after another long period has passed before us we find ourselves in a scene of *water, water everywhere*.

True, there is a line of shore where strange ferns and unknown club-mosses and reed-like plants are growing; but these only border the vast water-world, and we have reason to believe that no living animal wanders over that wild and barren country. But the water itself is full of life, though its inhabitants are of low kinds, as if Nature herself was as yet only half-awake.

Rich and rare seaweeds carpet the floor of the ocean, mingled with delicate flint-sponges and old massive corals ; beautiful feather-stars in the form of rooted stone-lilies wave their slender arms ; greedy star-fish, grazing sea-urchins, and all their many relations, grope upon the rocks ; and sea-snails crawl or float in countless numbers. The Nautilus, too, is there, with curious half-uncoiled companions of forms we have never seen before ; and huge sea-woodlice, the Trilobites of olden time with their three-ridged shields, burrow in the sand, or roll themselves up at the bottom of the water. And above all these, among many kinds of armour-covered animals, a huge form, nine feet long, like a lobster, with an imperfect head, rows himself along with his oar-like hind feet, seizing the smaller creatures with his long nipping claws in front. For we have travelled back to a time when the crustaceans were the most powerful animals in the world, and the huge lobster-like *Pterygotus* was the monarch of the seas.

It was in the midst of a scene such as this that we first find the feeble ancestors of the Sturgeon and the Shark beginning to make their way in the world. It may be that creatures such as the sea-squirts, the lancelet, and the lamprey, were there to bear them company, but these soft animals could leave no trace behind them, except, perhaps, the tiny teeth of the Lamprey. For they had no enamelled plates like the plated fish, no hard teeth-spines like the sharks, which could become buried in the soft mud when they died, and remain, together with the hard shell of their enemy the *Pterygotus*, to be dug out now in our day and bear witness to the fight they fought. But



the plated-scaled fish had something to leave behind, and from their remains we can picture to ourselves a group of clumsy fish scarcely a foot long, with hind fins like paddles and single-fringe fins on their back, with enamelled lozenge-shaped plates on their bodies and unevenly pointed tails. These fish would keep well out of the way of the *Pterygotus*, because they were small and weak and he was large and strong. We may imagine them gliding among the seaweeds, and hugging the shore as they chewed the plants with their flat-ridged teeth, for their skeletons were probably feeble and their armour-like shields were heavy, and they would not be so active as the little shark-like animals, not bigger than a half-pound perch, with tough skins and sharp spines, which swam more boldly out to sea. These more active fish were the founders of the shark group, and those sharp spines, together sometimes with the tough skin, remained buried in the mud, and have come down to us as fossils.\*

We should find it difficult to say exactly to what class all these early fish belonged, for there were very few kinds, and therefore fewer distinctions, between them in those days; and many peculiarities which afterwards appear in different groups either did not exist or were united in one fish. It is enough for us that they were the ancestors of our sharks and sturgeons and mud-fish of to-day; and though they were but small and weak, yet they were the beginning of a powerful race of creatures, for they had the great advantage of a growing inside skeleton, which could vary and strengthen with their bodies from generation to generation, while their rivals, the *Pterygotus* and his com-

\* *Ichthyodorulites*.

panions, had only their heavy cumbrous armour with a mass of soft flesh inside, and were but lumbering creatures at best.

And so we find that as thousands and thousands of years rolled by, the descendants of the enamel-shielded fish began to improve, and became larger and more powerful as the generations passed on, till they became masters of the shallow seas, and after awhile of the rivers and lakes. By the time that the first air-breathing creatures, the May-flies and Dragon-flies, had found their way out of the water into the forests of pines and tree-ferns on the land, and left their tender wings in the soft ground of the ponds and lakes, large fishes\* whose tails were uneven-pointed like the sturgeon,—whose bodies were covered with lozenge-shaped enamelled scales and their heads with shields,—were grazing along the shores and in the rivers and bays, with probably swarms of smaller kinds which have left no traces behind.

These were peaceable fish which fed upon plants, and among them were some curious forms with paddle-like fins and broad-ridged teeth, which, as they swam under the shade of the huge forest trees, would come to the top and take in air through their mouth. These were the distant ancestors of our present mud-fishes, and through all the passing ages, from the time of the coal forests till now, they have kept their fish-like form, so that we have their descendants among us now in the Australian *Ceratodus* and the mud-loving *Protopterus* of the Nile.

But besides these gentle vegetarians there were in the sea huge enamel-scaled monsters, with terrible

\* Dipterus.

jaws and gigantic teeth, floundering about and making great havoc among the crab-like animals. One of these, whose head-shield has been found in the ancient rocks of Ohio in America,\* must have been at least fifteen feet long, with a huge head, three feet long and a foot and a half broad; and no doubt there were many others like him, having a fine time of it now that they were the strongest creatures living. For this was the Golden Age of fishes, just before the time when the coal-forests grew; and the clumsy crab-like animals, and the trilobites, which had had their innings when the fish were small, now began gradually to be exterminated by their powerful enemies. Little by little they gave up the battle of life, and the larger ones died out altogether, leaving only those smaller crustaceans which did not clash with the fish.

So time passed on. The coal-forests grew, and died away and were buried; and as the ages rolled by a still stronger class of animals began to grow up which was to pay back upon the enamel-scaled fish the vengeance they had wreaked upon the crustaceans. For in the coal forests we first meet with creatures like our newts and salamanders, and after these came the true air-breathing reptiles (see Chap. v.), which swarmed over land and sea. There were the fish-lizards, with their strong swimming paddles and sharp teeth, and the swan-like lizards, with their long necks, which enabled them to strike their prey in the water; and these, together with the flying-lizards, and the huge dragon-like reptiles which haunted the shore, made the life of the

\* *Dinichthys*.



heavily-moving enamelled fish a burden to them. So they, in their turn, began to give way, and became smaller and rarer as the history went on, till at the time when the chalk-building animals were at work at the bottom of the sea we begin to lose sight of all but those few forms which linger still. It was about this time that the Sturgeon, as we now know him, became the chief representative of these old cartilaginous fishes, and to this day he and his children go on travelling up the rivers of Europe, Asia, and America, or crossing from sea to sea—a living example of those ancient races which ruled the seas of long ago.

The history of the small shark-like animals was rather different. They too grew strong and powerful before the reptiles came, and they did not afterwards lose much of their greatness. With the wide ocean for their home, and not troubled with the heavy enamelled plates of their companions, they kept clear of the monster reptiles, or struggled with them bravely. Some took to the open sea, and from them are descended the giant sharks of to-day which still remain masters of the ocean. Others still lingered near the shore, where we find quite new forms springing up; some, like the *Chimæra* or “King of the Herrings,” formed a group of their own, half-way between sharks and sturgeons; and some, slightly flattened like the huge Monk-fish, hide themselves in the loose sand when seeking their prey. Others, the Skates and Rays, with flat bodies, and long tails serving as rudders, shoved smoothly along with a wavy flapping motion of their broad arm-fins. These too lie chiefly at the bottom of the sea, where their dusky colour hides them both from

the fish they would wish to attack and those that would attack them ; for while the sharks trust to their strength, the skates and rays trust to stratagem, and, coming along stealthily in the shadow, flap rapidly over their prey and suck them into their open mouth below. And for further protection we find some of them, such as the Sting-rays, armed with barbed spines ; others, such as the Torpedo-fish, with electric batteries in their heads, which they can use to stun and kill their enemies ; while others again, such as the Saw-fishes of the Tropics, have the front part of their skull lengthened out in a long bony weapon, armed with teeth, which they use to rip open the bodies of their prey.

All these formidable fish are descendants of the shark family, which, with powerful gristly backbones, strong fins and tails, and highly developed brains, refused to be suppressed as their plated companions were, but found room in the wide ocean to do battle for themselves, and improve in many ways upon their ancestors. They do not, like the sturgeon and the bony fish, lay their thousands of eggs, but are content with one or two at a time, such as the leathery purse-eggs of the skate and the rough hound shark ; or give birth to a dozen or twenty living young ones. Yet they are so well fitted for their life that they flourish and keep their ground, so that while the enamel-scaled fish and the mud-fish are small groups, many of them fading away, the sharks and rays bid fair to be the race which will keep up the traditions of those quaint old Fishes of ancient times, which were once the masters of the world.



### CHAPTER III.

#### THE BONY FISH, AND HOW THEY HAVE SPREAD OVER SEA AND LAKE AND RIVER

WHEN the palmy days of the enamel-scaled fish had passed away, and the sharks and rays had taken up their various quarters in different parts of the sea, there still remained vast tracts and many snug nooks and bays admirably fitted for fish-life. But these



were not empty, for long before this time another order of fish—light, strong, and active,—had been pressing forward to take possession of every vacant space.

If we could dive under the water and watch the fishes at home we should see at once how much more agile and easy the bony fish are in their movements than their gristly companions. Look at a shoal of silvery herrings as they swim and leap and gambol, or a fine salmon sailing up the river or springing over a waterfall, or a tiny stickleback darting across the stream, and compare their graceful motion with the ponderous though powerful movements of an unwieldy shark. Any one who has done this will feel at once that though the sharks have still kept their power as tyrants of the sea, because they are so strong and big, yet these light skirmishers are much more at their ease, and move with much less effort in the water, so that it is natural they should have made their way into all parts of the rivers and seas. But where have they come from? We know very little of their early history, but what little we do know leads us to think that long ago they branched off from the enamel-scaled fish, and struck out a path of their own to make the most of the watery world.

Turn back for a moment to our little minnow, and recall his tender backbone made of joints hollowed out before and behind, with cushions of gristle between; those cushions, when the minnow was growing out of the minnow egg, were one long gristly cord, like the cord of the sturgeon, and it was only as the minnow grew that the bony joints hardened round it and separated it. Moreover, that huge bony pike

which we find now wandering in the American lakes has bony joints hollowed out like the minnow's, although by his enamel-scales and uneven tail we know him to be one of the ancient fishes. Some time or other, then, the sturgeon, the bony pike, and the modern minnow, must have had a common ancestor, though we should have to reach him through millions of generations. In the same way, too, we find the red-folded gills covered by a scaly lid, both in the sturgeon and the minnow, though in other ways they are not exactly alike; while even the V-shaped tail of the modern fish is not so different from the ancient shape as it seems, for the end of the backbone runs up into the top branch of the fork as it does in the uneven tails of the olden fish. Lastly, the delicate rounded scales on our minnow's body are not entirely the property of bony fishes, for we find such scales on the mud-fishes, the *Amia* and *Ceratodus* (see p. 33); while the little modern stickleback, on the other hand, has bony plates, reminding us of those of olden times. We see, then, that the bony fish still carry upon them many signs of their origin from the older fish, and when once the coast was left clear, and they got a fair start, we can easily imagine that the fish of this younger race which was still in its childhood, and easily moulded to suit different kinds of life, would press forward in every direction and make the most of every chance.

And so we find that little by little, from the time of those chalk seas till now, the remains of enamel-scaled fish grow rarer and rarer in the hardened mud, and the bones and scales of modern fish take their place, till this bony race has spread so far and wide

that in our own day, if we were to start from the head of a river and swim down into the open sea of the Atlantic or Pacific, we should meet on our way bony fish of all shapes and sizes and habits of life. River-fish and lake-fish and sea-fish ; shore-fish, surface-swimming fish, and fish of the deep sea ; flat-fish like the sole, half hidden in the sand, and long rounded fish like the eel, threading their way through holes and passages all over the world ; flying fish with long arm-fins, and clinging fish whose fins form a sucking disk ; nay, even so strange a thing as an angling-fish, whose back fin is turned into a fishing-rod to attract his prey.

All these, during the long ages since they first started in life, have been learning to make use of some area in the wide expanse of water spread over our globe, and it remains for us now to see how they have succeeded. Where shall we make our start ? If we begin at home in the rivers we should have to work, as it were, backwards, for the sea is the chief home of fishes, and the rivers only the refuge of a few stray kinds. The sea-shore would be, perhaps, our truest starting-point, but then we should have to travel two different ways. Will it not be best to dive down first into the silent depths of the ocean, and learn what little is known of those which have taken refuge there ? Thence we can rise up to the open sea, from there swim in to the shore, and then up the rivers and back to our own land-home.

It makes but little difference where we take our plunge into the deep sea, for changes of climate are scarcely or not at all known there, and the fish seem to wander over every part. Wherever it may be, then,



—let us say in the seas of the Tropics, which have given us most of our specimens—let us dive down, down, till we reach about 1800 feet (300 fathoms).

. . . “ For who can know  
What creatures swim in secret depths below,  
Unnumber'd shoals glide thro' the cold abyss  
Unseen, and wanton in unenvied bliss.”

We shall be groping more and more in darkness as we go, for the sunlight scarcely reaches beyond 1000 feet, and we have left its last rays behind us, and the water is growing icy cold. How strange, then, that the first fish we meet should have large wide-open eyes! This is the *Beryx*,\* shaped something like a perch, but about a foot and a half long, and generalogists ought to look at him with respect, for his ancestors (see heading of Chapter) are almost the oldest known bony fish, and lived in the chalk seas.

Has he come down here because the upper-world was too rough for him? If so, he has found comparative stillness, for he is far beneath the turmoil of the waves, and only the slowly creeping currents make any movement around him. But he has not escaped from the struggle for life, for not only is a good-sized shark coming his way, but a huge monster of the bony race, six feet long,\* with wide-opened jaw, sharp pointed teeth, and large keen eyes, is wandering near in search of prey, devouring large and small fish with great impartiality.

Still in the dense darkness the *Beryx* must surely escape? No! for, strangely enough, lights are travelling about in this midnight region. The monster

\* See Frontispiece. 1, *Chauliodus*; 2, 9, 10, 11, *Harpodon* or *Bombay Duck*; 3, *Plagiodus*; 4, *Chiasmodon*, with a *Scopelus* in its stomach; 6, *Beryx*; 8, *Scopelus*.

himself carries lamps upon his body, and a shoal of small oblong fish, something of the size and shape of a gudgeon, come swimming by, carrying on their sides whole rows of shining spots giving out phosphorescent light ; while not far off another fish, called in India the Bombay duck, glows all over, as if his whole body had been rubbed in phosphorus. Nay ! so far as we know the Beryx himself is probably gleaming with light, for his body is covered with a large quantity of the same slimy fluid which makes the "Bombay duck" phosphorescent when he is freshly drawn out of the sea.

So these curious fish, living in eternal darkness except when they make an expedition to the surface, carry many of them their own lights ; and as we go deeper still more and more of them are found with shining mother-of-pearl-like spots on their head, or sides, or tail, so that the very darkness is alive with light. What slaughter and hunting there is among them ! for they all eat each other, and even their own young, there being no plants for any of them to feed on. There are the deep-sea cod-fish ; strange forms with large heads, long tapering tails, and thread-like fins, chasing the smaller fish, and falling victims themselves to the fierce *Stomias* which comes sailing along with its row of glowing lights, and its huge sharp teeth, ready to seize its prey. Both these fish go down as deep as ten thousand feet and more, accompanied by another fish quite as ferocious, though only a foot long, with large teeth sticking out of its mouth like the tusks of a boar, and curious round spots, with lenses in them, on its side, which may be eyes, or may be lanterns to light it on its road ; and among these luminous fishes are wriggling

along the deep-sea Conger eels, with toothless mouths and elastic stomachs, swallowing large fish whole ; while another curious cod-like fish, whose stomach can stretch to more than four times its natural size, draws itself over its prey just as a snake does, and carries it in the hanging bag till it is digested. And deeper yet in the dead calm water roam many fishes with delicate feelers hanging from their mouths, while their fins are slender and tapering, so that they feel their way along the still depths. Among these are the Ribbon-fish, twenty feet long but only a foot deep, and never more than two inches thick in any part, with their long rosy fins floating like ribbons back from their heads and from under the body.\*

Strange monsters are all these deep-sea fish, some of them living as much as 16,000 feet under the surface of the sea, so that if Switzerland were turned upside down in mid-ocean, the peak of Mont Blanc would not reach down to where they swim. Yet they are only modified forms of ordinary fish from the world above, which have become fitted to live under that vast pressure of water. Their skeletons, though bony and well-knit together at that depth, are fibrous and slight compared to those of their surface relations, for although they have to resist a weight of from two to sixteen tons pressing all round them, a ton weight being added for every thousand feet, no special strength is required, because the dense water permeates their whole structure, and the pressures are everywhere equal. It is the same with them as

\* In drawing up this sketch of the deep sea I am almost entirely indebted to Dr. Günther's masterly sketch of the deep-sea fish in his excellent work.



with the most delicate and fragile insects living in our atmosphere, the pressure of which would tear them to pieces if unbalanced by equal pressures within and without.

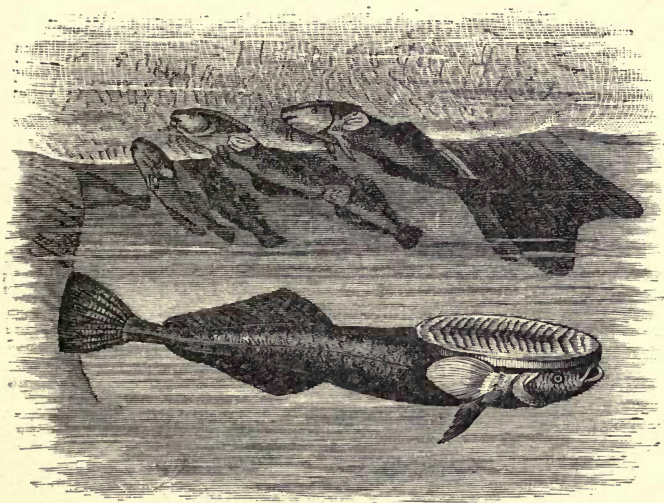
But when these deep-sea fishes are brought up quickly to the surface, the outside pressure no longer balances that inside, and so their tissues loosen and their whole framework starts apart, so that they almost fall to pieces at a touch; and their air-bladder, if they have one, expands so much as to force the stomach out of the mouth, turning them almost inside out. Neither are their lanterns a special creation for their use, but merely adaptations of that slimy fluid which we saw oozing from the scales of the minnow. In some of the deep-sea fish even the outer bones are filled with this fluid, and the line of scales along the side has large openings, so that the body is bathed in glowing slime. In others it collects in glands on the sides, making the phosphorescent spots.

In this way the deep-sea fish have become fitted to make a home in the very heart of the ocean. Some with large eyes, seeing by means of their own and their neighbours' light, others with small eyes and delicate feelers, testing each step as they go, and feeding, probably, on the shower of minute sea-animals that falls continually from above; while some, like the *Beryx*, the Bombay Duck, and the light-carrying *Scopelus*, which live nearer the top, come up on still nights to feed at the surface of the sea.

And now, as we rise again from the dark still depths up to warm layers of the tropical seas into which the sun is pouring his penetrating rays, it may

happen that a large dark body moves between us and the surface, as the Great Blue Shark, or one of his smaller relations, ploughs his way through the water. But what are these little dark brown fish, with round gaping mouths, which are hanging by the top of their head and back from under the shark's belly? (see Fig. 9). Where he goes they go with him,

Fig. 9.



Remoras \* clinging by their sucking-disk to the under part of a shark.—(*Adapted from Brehm.*)

and, as they are borne along, they feed upon the tiny sea-animals among which they are carried so easily. These cunning passengers, of whose very existence the shark seems unconscious, are the Remoras, or sucking-fish. You would scarcely think that they

\* *Echeneis remora*.

belong by descent to the mackerel tribe, a strong-swimming, active, and almost warm-blooded group of fish, with a large supply of nerves and blood-vessels to their muscles, so that they swim boldly out to sea, and make more use of the open ocean than almost any other group. But among all tribes there will be some weak members, and these must live by stratagem. The little remora is a feeble swimmer, and, having to live out at sea, has acquired a curious sucker by which he clings to sharks, and whales, and even ships, so that he is carried along without exertion. Yet this sucker, again, is only a special adaptation of the back-fin, which, instead of being single, as in other mackerel, has its spines divided and bent, one set to the left, the other to the right, and joined by a double set of plates, surrounded by a fringe of skin. This forms an oval disk, and, as the remora glides along under the shark's belly, he presses the damp membrane against the fish, and, drawing together the muscles of the plates, clings as firmly as a limpet to a rock.

Nor is the remora the only companion of the shark—

“ Bold in the front the little Pilot glides,  
Averts each danger, every movement guides ;”

for the little steel-blue striped Pilot-fish,\* another distant connection of the mackerel tribe,† is hovering around, feeding upon the scraps of the shark's food, and finding protection in his neighbourhood, though in olden times he was supposed to protect the shark.

\* Naucrates.

† In this description I am not alluding simply to the mackerel family Scombridæ, but to that much larger group *Cotto-Scombriformes*, to which so many ocean fish belong, and even the sword-fish is allied.



A brave little fish this, which has succeeded in making the shark his friend : while near him he is safe from other fishes.

And now, as we continue our way in the open sea, it is nearly always forms more or less related to the mackerel tribe which cross our path. The slender Bonito \* and the heavier Tunny † sometimes ten feet long, are hunting below or on the surface, and the beautiful Dorados, ‡ or gold-mackerel, as the Germans call them, with their silvery blue backs tinged with a sheen of gold, their dull-coloured fins, and their golden eyes, are driving by in large shoals in pursuit of the flying-fish. All these are powerful swimmers, and they have no air-bladder, which is an advantage to such active hunters which wish to turn rapidly, to go down deep or rise to the top, and change their position at every moment ; for in all these movements a natural float inside is a hindrance to be overcome. And so we find that in fish, even of the same family, some have lost the air-bladder, while others have it enlarged to meet their wants, as in the case of the lovely blue and silver sun-fish § for example, which, though quite near relations of the dorado, have very large air-bladders, enabling them to float quietly on the top of the water, waving their deep scarlet fins.

But while we are watching all these large and strong swimmers an active and bloodthirsty struggle is going on, for the bonitos and the dorados are looking to make their meal upon the little Flying-fish, which are straining every nerve to escape them, while here and there

\* *Thynnus pelamys*.  
Coryphæna.

† *Thynnus thynnus*.  
§ *Lampris luna*.

one drops down into their very mouths. Lovely little creatures these are, of the Pike family, which have taken to the open sea, where they rise with a stroke of the tail many feet out of the water, their bright purple backs and silvery sides gleaming in the sun, as, with their long transparent arm-fins outspread, they

Fig. 12.



Flying-Fish\* pursued by the Dorado.†

float for as much as two hundred yards before they fall back, to spring up again with another stroke. Their air-bladder, which is half as long as their body, and contains in a six-inch fish as much as three and

\* *Esoxetum*.† *Coryphæna*.

a half cubic inches of gas, stands them in good stead, and they rise and fall with quick rapid flights out of the reach of their foe, so that in the open sea they do fairly well on the whole, though, if they venture near land, the sea-birds persecute them in the air. Nor do they stand alone in this curious habit of flying, or rather floating, in the air, for a larger fish of quite another family, the "Flying Gurnards,"\* with a smaller but still ample air-bladder, and long arm-fins, may also be seen rising in the Mediterranean and tropical seas, out of reach of the fish-hunters of the water.

And now we must leave the open sea and steer for the shore. It is true that many other fish are wandering in the broad watery main, but many of them, such as the globe-fish, feeding on the small crustaceans and the sea-horses,† whom we shall meet nearer shore, are feeble forms carried hither and thither by currents or on floating banks of seaweed, while others have no special interest. The sharks, the mackerel, and the flying-fish, are the most remarkable colonisers of the ocean-surface, for even the enormous Sword-fish,‡ which attacks the bonitos and whales with its long wedge-shaped bony jaw, and is said to sail by raising his back-fin, is a distant off-shoot of the mackerel tribe.

So we cannot do better than follow our own common Mackerel, as they migrate in shoals out of the deep sea to feed on the fry of the herring or the pilchard in shallower water, or to leave their eggs floating not many miles from land, so that the tiny mackerel, when hatched, may live in the quiet bays till their strength comes.

\* *Dactylopterus*.† *Hippocampus*.‡ *Xiphias*.



But stop ! Long before we have come so far as this, and while we are still a hundred miles or more from the shore, let us peep down into the sea-valleys, where forests of seaweed and marine plants are growing, and myriads of tiny sea-lice and crustaceans throng the water. What is that army of thin spindle-shaped forms rising and falling in such numbers ? It is a shoal of herring, which have come there to feed upon the sea-animals, keeping out of sight of the sea-birds above, and the cod and sharks and ravenous fish which hunt them without mercy, so that they only venture to come to the surface on calm dark nights. It was in valleys such as these that the herrings were living when the older naturalists thought they were gone away to the Polar Seas, because they only saw them in spring and autumn, when they come into shallower water to drop their myriads of eggs,\* which sink down, and stick to the seaweed and stones below.

But now they are revelling in the deep ocean, rising and falling with ease, for their air-bladder has two openings, one to the stomach and one to the outside of the body, so that the gas can adjust itself to their movements ; and surely if the shark is the type of the old, lumbering, powerful, slow-breeding fish, the herring, with its narrow lissome body, light playful movements, and myriads of young, is the type of the new and active race. They are as truly social animals as any herds on land, for they travel in shoals of many hundreds of millions ; and as they can squeak, and have a very good apparatus for hearing, it is more than likely that they call to each other. They

\* At least 10,000 for each mother.



make both the salt and fresh water their own ; for when the eggs are hatched at the mouths of rivers the tiny fish take refuge there from the violent persecutions of the cod and mullet and haddock, flat-fish and whiting, and, together with the small fry of other fish, stroll up the rivers, where we call them "white-bait."

And now, as we come nearer to the shore, where countless numbers of small fry are filling the water, and all creatures are struggling together to accomplish three objects, namely, to get food, to avoid being turned into food, and to lay their eggs, we find many strange weapons and devices adopted by the different fish for protection and attack.

. . . . . " Each bay  
With fry innumerable swarms, and shoals  
Of fish, that with their fins and shining scales  
Glide under the green waves, in sculls that oft  
Bank the mid sea."

There are the Mulletts,\* with tender feelers under their chin, with which they brush the ground lightly as they swim, feeding on the tiny creatures. There are the walking fish, the Gurnards,† which have three of the spines of their arm-fins separate, and moved by strong muscles and nerves, so that they can walk on the sea-bottom, feeling their way, while the stiff, spiny rays of their back-fin stand up to wound any enemy attacking them from above. There are the tiny Blennies which walk too, but by means of the few rays which alone remain of their leg-fins growing close under the head. Then there are the clinging-fish, the Gobies,‡ living on the rocky shores, where

\* Mullus.

† Trigla.

‡ Gobidæ.

the waves beat and roar, and they have their leg-fins joined together, so as to form a kind of funnel under their throat, with which they cling to the rocks and then dart across the waves to feed, coming to anchor again out of the dash of the water ; some of these little fellows make nests and guard their eggs after the mother has left them, till the young can shift for themselves. More curious still, the Lump-sucker\* has its arm-fins and leg-fins all joined together into a round disk under the throat, and so holds on bravely against the dashing tide, defending the eggs which have been laid in the seaweed near the shore, and even remaining to take up the young ones when hatched, and carry them safely back into deep water as they cling to his sides.

Meanwhile, close down upon the sand are the hiding-fish, the Weevers, the Anglers, and the Flat-fish.

The weevers† are the most dangerous. Their shaded yellow colour hides them from view, while the sharp spines of their back-fins, which they keep raised, will inflict very severe, if not poisonous, wounds on any creature striking against them. Nor is this all, for behind the cheeks, fastened on to the horny gill cover, are daggers with which they can strike, deliberately jerking them back so as to give a sharp blow. These are fighting aggressive fish, waging the war that goes on so sharply all round our coasts.

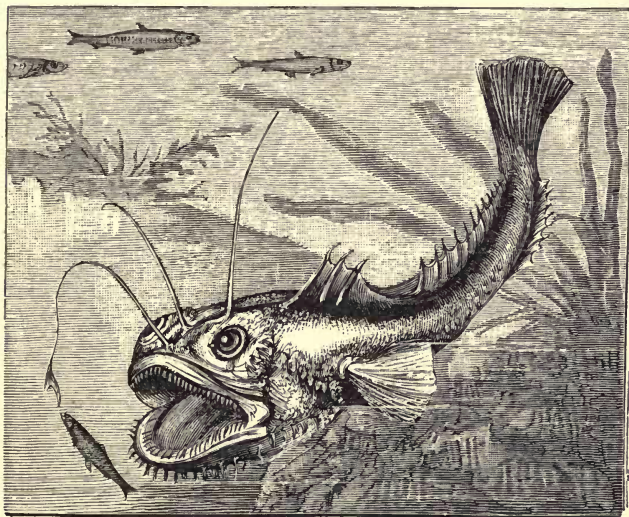
But there is one even more cunning than they, lying hidden in the seaweed or the sand—a large, flat, soft fish, about three feet in length, and quite half as broad as he is long, with a soft stumpy

\* *Cyclopterus*.

† *Trachinidæ*.

tail, stretching out behind, and a kind of wrist-joint to arm and leg fins, by which he can creep noiselessly along. His wide mouth is gaping open, so that a two-foot rule could be passed crossways into it, and his pointed teeth are bent back to allow his prey to enter. But how is this prey to be

Fig. 11.



The Fishing Frog.\*

caught, for he is not going to move to fetch it? Notice all round his head and his body, the skin is fringed like blades of seaweed and plays about in the water; while above his head and back the spines of his fin stand up quite separate, and the front one

\* *Lophius piscatorius*.

is tapering and long like a fishing-rod, with a lappet at the end like a bait. And now, as the shallow water ripples over his head, the lappet plays to and fro, and the unwary fish come up to nibble at it, lower and lower he waves it, and the nibblers follow, till, opening his wide gape, he gulps them down, even if they are as large as himself, and lies passive with his swollen stomach till they are digested. This is our own Fishing-frog,\* of which one was once found with seventy herrings in his stomach. He has relations all over the world—in the open sea and down in its depths, and all of them more or less follow his fishing habits. Yet there is no creation of special parts for these strange weapons ; the altered back-fin and the jagged skin do all the work, just as in some curious fish of the weever family in the tropics, called the Stargazers,† the feelers on their lips, longer than those of other fishes, and a lengthened thread from below the tongue, play in the watery currents and attract the small animals, while the fish with upturned eyes watches them as they are lured to destruction.

Lastly, among all these curious forms upon our shores there is an abundance of flat-fish—soles and turbot, brill and plaice—flapping along at the bottom, covering themselves with sand, or rising up with that strange wavy movement of the whole body in which they use what look like long side-fins, but which are really the back-fin and the belly-fin.

If we wanted to pick out the strangest and strongest proof of how the shape of fish is altered to suit their wants, we need seek no further than the flat-fish.

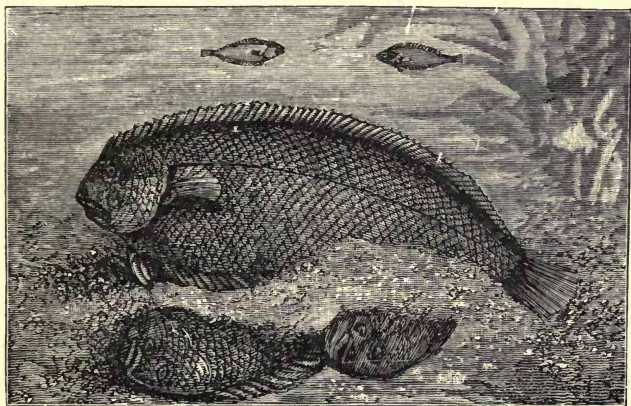
\* *Lophius*.

† *Uranoscopus*.



When we were speaking of the shark order we saw that the rays and skates are flattened forms suited to hide in the sand, and these fish are truly spread out as if they had been squeezed under a heavy weight, their broad arm-fins edging the sides of their body. But the bony flat-fish, the Soles and Turbot, have a far stranger history. The young sole, when it comes

Fig. 12.



The Common Sole.\*

Above are two small soles as they swim when young. At that time they are not larger than a grain of rice.—(*Adapted from Figuier and Malm.*)

out of the egg, is not flat like the young skate, but a very thin spindle-shaped fish, something like a minnow. He is then about the size of a grain of rice, very transparent, and lives at the top of the sea.

\* *Solea vulgaris.*

He has one eye on each side, like other fish, only one eye is higher up than the other, and the single fin on its back and the one under its body reach almost from head to tail. In this way he swims for about a week, but he is so thin and deep, and his fins are so small, that swimming edgeways is an effort, and soon he falls down on one side, generally the left, to the bottom of the sea. Many times he rises up again, especially at first, till he has got used to breathing at the muddy bottom, and meanwhile the eye that lies underneath is gradually working its way round to the upper side, his forehead wrinkles so as to draw the under eye up, while his whole head and mouth receive a twist which he never afterwards loses. His skeleton, it must be remembered, is still very soft, and the bones of his face are easily bent; and at last this eye is screwed round, and as he lies at the bottom he can look upwards with both eyes and save the under one from getting scratched by the sand, as it must have done if it had remained below.

Nor is this all, for while his under side, shaded from the sunlight, remains white and colourless, his upper side gradually becomes coloured like the sand in which he lies, and he is safely hidden from attack as he flaps along, feeding on worms and other animals. And now when he swims he no longer uses his arm and leg fins, which are quite small and insignificant, but bends his whole body, using the back and belly fins to help him. What we then call the top of the sole is really his side, where you may see the dark line of scales running along the middle, and one arm-fin lying close to his head. Yet he can swim strongly and to far distances, for in the winter the soles, too, migrate

into the open sea, where they may be found in the deep water of the Silver Pit, between the Dogger Bank and the Well Bank.

And now, before we leave the shore, we must glance at a curious weakly little fellow clinging by his curly tail to the seaweed, whom you will certainly not take for a fish, even if you can find him out, so entangled is he generally in weeds of the same colour as himself. Yet the Sea-horse \* is a true fish, covered

not with scales but with plates, with which he makes a clicking noise by scraping them together. What look like large ears are really his arm-fins, while at the end of his long snout is a mouth shaped like an ordinary fish's mouth, but toothless, and he breathes with fish's gills arranged in round tufts instead of folds. What the use of his strange shape is to him we cannot tell, but at any rate

his fleshless bony body must protect him from other fish, while his power of clinging causes him

Fig. 13.



Hippocampus, a fish commonly called the Sea-Horse.

\* Hippocampus.

to be often carried by floating weed even into the open ocean, and make up for his feeble powers. In one thing he surpasses most other fishes, for he is a most careful father, carrying the mother's eggs in a little pouch under his body till the young ones escape. There is one form of these sea-horses in tropical seas which has long red fringes floating from its body, so that it cannot be distinguished from the seaweed in which it hides.

So we see that the deep sea, the open sea, and the shore, are filled so full of different forms that there are enough not only to make use of every part, but also to provide food for each other, and we also see that by far the larger number even of widely-spread fish come near to the shore to leave their spawn, while the young ones often make their way into the brackish water at the mouths of rivers, and spend their youth in the shelter of the still fresh water.

Now it is very natural that many such fish should learn to remain in this quiet refuge, and in time to live there altogether. And because fish-life in the rivers is comparatively uneventful and little varied, we find much fewer peculiarities in river-fish. Many of them are very near relations of sea forms. There is the salmon, a true sea-fish, which wanders up the river to spawn in the pebbly shallows ; and there are the trout, his near relations, which have learned to live entirely in the rivers. There are the sea-perches, large strong fish, and the smaller river perch, which have made their homes very successfully in the rivers, for their spines are so sharp that even the greedy pike hesitates to swallow them. There are







Fig. 14. STICKLEBACKS AND THEIR NEST.—(*Gasterosteus aculeatus*.)

the sea-sticklebacks, and the little river-stickleback.\* This last is a very clever little fish, which hollows out the foundation of his nest very carefully in the bed of the river, and then builds it up for several inches with blades of grass and weeds (Fig. 14), gumming them together with the slime of his body. Then, when all is ready, he swims about to drive and coax the mother to the nest, sending her in to lay her eggs, and then driving her right through and out at the other side, so that a stream of water flows constantly over the eggs till they are hatched. Nay, his care does not end here, for when the young fish come out of the egg with a bag of yelk hanging under the body, as all young fish have at first, and so cannot swim easily and escape their enemies, the courageous little father will defend them and fight fiercely with any fish which thinks to make a meal upon them, not leaving them till all the yelk is absorbed, and they are able to swim and feed themselves.

Besides these active river-fish there are the little stupid Miller's Thumbs,† hiding under the stones to feed on tiny animals; they are feeble relations of the gurnards which we saw walking on the bottom of the sea. Then there are the purely freshwater fish, the Pike and the large Carp family, with its many branches, the Roach, and Dace, and Gudgeon, and Minnow; and the enormous family of Cat-fish and Sheat-fish,‡ of which we have none in England, but plenty in America and other parts of the world, a family in which the fathers sometimes carry the eggs in their mouths till hatched. And last but not least among the freshwater forms is that irre-

\* *Gasterosteus*.† *Cottus*.‡ *Siluridæ*.



pressible family of the Eels which we saw wandering in the deep sea, and which are also to be found near the shores all over the world. These fish will even travel through pipes and into cisterns ; and will climb up trees so as to drop into neighbouring streams and continue their wanderings ; they sleep in the mud in winter ; and even after being frozen come to life again ; and in the spring they go to the sea to spawn, giving rise to those shoals of young ones from three to five inches long which come in incredible numbers up the rivers in summer, making the eel-fairs,\*—

“ The silver eel, in shining volumes rolled,”

so much spoken of in old books, when the eels will often climb high banks, nay, even pass over miles of dry land, closing down their narrow gill-openings, and so shutting in water to serve them as they go.

All these, and many other freshwater families, show us how the fish have wandered into every possible nook of the waters, so that even in those inland salt lakes of North America and Asia into which no rivers flow fish-life is abundant ; and we can only suppose that the eggs must have been carried by water-birds in their flight, or by gusts of wind, or have arrived there in ages long ago, before these lakes were cut off from the rest of the watery world.

Yet some few fish besides the eels have been known to travel over land to find watery “ pastures new ;” the Climbing Perch† of India and the Doras

\* More properly eel-fares (*fare*, Saxon, to travel ; ex., way-faring man).

† Anabas.



of Tropical America will both travel many miles when their own ponds are dried, the perch breathing by the help of a special apparatus, and the doras probably shutting water into its gills; for necessity, even in fishes, proves the "mother of invention," and in special works on fish you will find accounts of numberless strange devices and adaptations by which they manage to survive in the struggle for life.

And now, collecting together all we have learned, let us in conclusion form a rough picture of the history of the fish-world. All over our globe, from pole to pole, and from the Indian Ocean round to the east, back to the Indian Ocean again, is one vast world of waters, with inlets and land-locked seas bordering its margins, and rivers pouring into its depths. In the past ages of the world these rivers and coasts and inlets have varied innumerable times, but the great ocean-mother has always been there to bear the increasingly-varied forms in her bosom, and to enable them to wander where best they could preserve life.

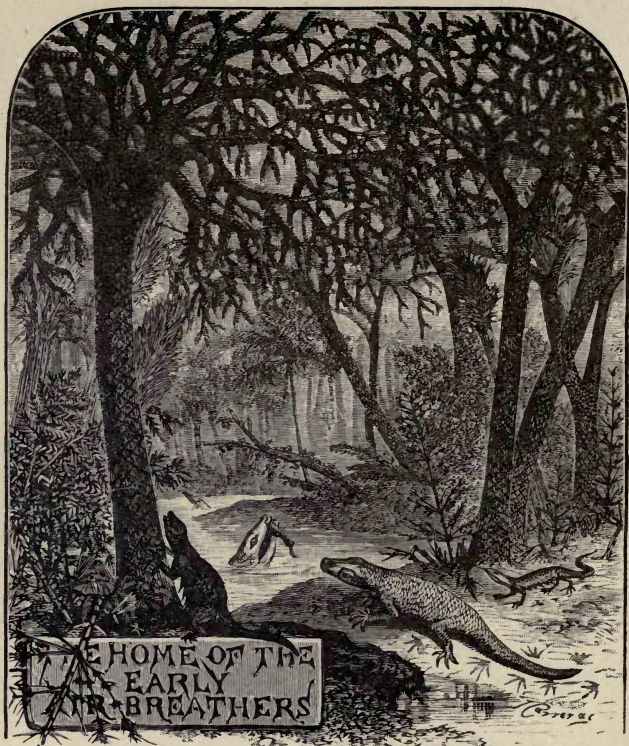
And so from their beginning, when they were probably as feeble as the lancelet, these earliest and simplest backboned animals with their two pair of limbs as yet very variable both in their position and shape, have been spreading far and wide over the watery three-quarters of the globe. We have seen how the enamel-scaled fish had their time of glory, but were not able to hold their ground, because they were not agile and fish-like enough to escape their foes; and how the sharks by their strength and boldness remain monarchs of the sea to the present day. Then we have seen that in old chalk seas the new

and active race of bony fish appear in force ; some like the herring and the carp, with air-bladders, which had openings like the enamel-scaled fish, and these can dart from heights to depths ; while others had closed air-bladders, and these remain with most ease at one level, and can sometimes, if necessary, use the gas in their bladder for breathing, if they are oppressed with muddy water ; and lastly, some, such as the dorado, have lost their air-bladder altogether, and gain in freedom of action what they lose in lightness and buoyancy. And during the ages that have passed since this bony race began, different branches each in their own way have thrown out curious weapons and developed strange organs to help them in the battle of life, so that now we have deep-sea fish carrying their own light ; fish with distensible stomachs swallowing prey larger than themselves ; fish with large air-bladders and long arm-fins springing out of their own element and floating in air ; angling-fish, walking-fish, clinging-fish, and hiding-fish ; and even those whose shape is distorted, like the sole, to enable them to hide and hunt in safety ; while, when the sea is full, we find new varieties pressing their way into every river and tiny stream, and even overland into enclosed waters. Nay ! when we descend into the recesses of the earth and visit the underground pools of the dark caverns of Kentucky, there we come upon fish which have found a refuge in eternal darkness, and have lost not only the power of sight but actually the eyes themselves.

And here we must leave them to go to higher vertebrate animals. Although but little is known of fish-life, a very small part even of that little

has been given here, and yet we take leave of it with the feeling that its changes and chances are greater than we can ever thoroughly learn. How much pleasure these creatures have in their water-world it would be difficult for us to say ; but since we find them playing together, hunting together, sporting in the warm sunshine, and diving and gambolling in the open sea, and sometimes even calling to one another, we cannot but think that life has great charms for them in spite of the many dangers surrounding them. And when, low though they are in the scale of life, we find them (though curiously enough always the fathers) carrying the eggs, building nests for them, and defending the young, we see that even here, in the very beginning of backboned life, we touch the root of true sympathy, the love of parent for child.





## CHAPTER IV.

HOW THE BACKBONED ANIMALS PASS FROM WATER-BREATHING TO AIR-BREATHING, AND FIND THEIR WAY OUT UPON THE LAND.

So the backboned animals, as fish, have peopled the seas and rivers, and, as the ages have past on, have become more and more fitted to their watery life, little dreaming of another and different life in the



world of air above them. And yet in the same pond with the little stickleback, so busy building his nest, there is a creature which could tell him that it is possible to live in both worlds, if only you have the proper machinery to do it with.

It is clear that if the backboned animals were ever to live upon land, after they had begun their career in the water, there must have been some among them which learned gradually to give up water-breathing, and to make use of free air; and we shall not have far to seek for creatures which will help us to guess how they managed it.

From almost every country pond, or ditch, or swamp, a chorus of voices rises up in the springtime of the year, calling to us to come and learn how Life has taught her children to pass from the water to the air; for it is then that the frogs lay their eggs, and every tadpole which grows up into a frog carries us through the wonderful history of an animal beginning life as a fish with water-breathing gills, and ending it as a four-legged animal with air-breathing lungs.

Come with me, then, to some stagnant pool in a country lane, towards the end of March, and there we shall no doubt find a whole company of frogs, croaking to their hearts' content after their long winter sleep in the mud at the bottom of the pond. They are wide awake now, and are actively employed laying their eggs. Look carefully around the edges of the pond, especially in that part where the wind has driven the scum to the side, and you will doubtless find in some still corner a gluey mass (e, Fig. 15), which looks like a lump of jelly with dark specks in it. Take this up carefully, for it is

frog spawn ; carry it home together with some weeds from the pond ; put it in a glass bowl with water ;

Fig. 15.



Metamorphosis of the Frog.

*e.* Eggs. 1. Tadpoles just out of the egg. 2. With outside gills. 3. With gills hidden, and beak-like mouth. 4. Hind legs appearing. 5. All legs grown, but fish-tail remaining. 6. Putting on Frog appearance ; tail being absorbed. 7. Young perfect Frog.

and then from day to day you may study the history of a frog's life.

That jelly-like mass is a collection of frog's eggs. When they were laid, each egg was a small round dark body in a gluey covering, and they all fell to the bottom of the pond, where, by degrees, the water oozing through the envelope swelled each egg, till they clung altogether in a mass, and, rising, floated at the top. Then very soon each round dot lengthened out into a long streak, and in a few days an eyeless head appeared at one end with a soft closed mouth under it, and at the other a tail, with a soft fin round it like the tail of the lancelet; so that by the time you find the spawn, you may, most likely, be able to see the tiny creature wriggling every now and then in its watery bed. This will go on for some time, and a week or two may pass before the moving tadpole breaks through its egg skin, and coming out into the world, fastens on to a piece of weed (1, Fig. 15) by two little suckers behind its mouth. And now that it is out of the egg the interest begins. Look carefully day after day and you will see some branching tufts (2, Fig. 15) growing larger and larger on each side of its head. What are these? We have not seen them in any fish. No! but if you take a young hound-shark out of his leathery egg before his time, you will find that he has outside gills much like these, only he loses them before he comes out into the world, whereas the tadpole keeps them to breathe with a little longer. If you put the tadpole, at this stage, under the microscope, you can see the red blood flowing through these gills to take up air out of the water.

Meanwhile the tadpole's lips are gradually forming into a round mouth, much like the lamprey's,

and by-and-by the inner part of this mouth is covered with two little horny jaws, forming a sharp beak (3, Fig. 15) with which he will nip off pieces of weed for food. Meanwhile, as he grows larger and larger, and eyes, nostrils, and flat ears form in the head, a covering begins to grow back over the sides of the neck, and little by little the branching tufts disappear (3, Fig. 15). How, then, can he breathe now? Watch carefully and you will see that he gulps every moment as we saw the minnow doing (p. 23). The fact is that the outside tufts have faded away, and under the cover the tadpole has six slits in his throat, like the slits of the lamprey, which are covered in somewhat similar fashion to those of the amphioxus (see p. 11), and he breathes through them.

Here is our tadpole, then, to all intents and purposes a fish. He swims with a fish's tail; he gulps in water at his mouth, passing it out at the slits in his throat after it has poured over his fish's gills. Moreover, he has a fish's heart, of two chambers only, like the minnow's (p. 23), which pumps the blood into these gills to be freshened, while, like the lamprey, he has a gristly cord, enlarged at the end to form a gristly skull, a round sucking mouth, and no limbs. All this time, however, though he has a fish's fin round his tail, he has no arm or leg fins. Wait a while and you will see that under his tender skin far more useful limbs are being prepared. As he grows bigger and more active week by week, wriggling among the weeds and feeding greedily, two little bumps appear one on each side of his now bulky body, just where it joins the tail. These bumps grow



larger every day, until, lo ! some morning they have pierced through the skin, and two tiny hind legs (4, Fig. 15) are working between the body and the tail. The two front legs are longer in coming, for they are hidden under the cover which grew over the gills, but in about another week they too appear, and we have a small four-legged animal with a lamprey's tail (5, Fig. 15). These legs are something far in advance of fish fins, for they have shoulders and thighs, arm and leg bones, wrist and ankle bones, hand and foot bones ; and instead of the large number of rays in a fish's fin they have four fingers on their short front legs, and five toes at the end of long hind ones ; the toes being joined together by a web, which helps him wonderfully in striking the water as he swims.

The tadpole has now become fitted to jump and leap on the land or swim by his legs in the water ; and, moreover, while these legs have been growing, another change has been taking place. You will notice by careful watching that at first he still gulps in water as he used to do, but he comes more often to the top, and, poisoning himself so that his mouth is out of the water, gives out a bubble of bad air, draws in some fresh, and goes down again. Why does he do this ? Have you any recollection of another fish-like animal which comes up to take in air ? Look back at our friends the mud-fishes (p. 34), and read how the *Ceratodus* fills his air-bladder when he is short of good air in the water. When you have re-read this, you will suspect that the tadpole, too, has something like an air-bladder, which he fills from time to time. And so he has. While his legs are growing a bag has been forming inside at the back

of his throat, which afterwards divides into two, and he fills these by shutting his mouth, drawing air in at his nostrils, putting up the back of his tongue to shut it in, and then swallowing it down into the lungs ; so that he is now a truly double-breathing animal, using his gills when below water and his lungs when above. Moreover, if you could watch inside his body, you would now see that little by little the blood-vessels going to the gills grow smaller and smaller, and those going to the lungs grow larger and larger ; while the fish's two-chambered heart divides into three chambers, one to receive the blood from the body, another to receive it from the lungs, and one to drive this blood back again through the whole animal. And when at last this change is so complete that all the blood goes to the lungs to be freshened, the gills shrivel up and disappear, and our tadpole is a true air-breathing animal.

Notice, though, that he is still cold and clammy, not warm like a mouse or a bird. For his blood still moves slowly, and as he has only three chambers to his heart instead of four, as warm-blooded animals have, the good blood from the lungs and the worn-out blood from his body become mixed each time they come round, so that his breathing work is still of a low kind all his life. And now that he can leap and swim with his legs, his tail is no longer of use to him, and it is gradually sucked in, growing shorter and shorter till it disappears, and the young frog is complete.

Thus our backboned animal has succeeded in getting out of the water on to the land, and in doing so he has quite changed his habits. A peaceful vegetarian before, he is now a greedy eater of

insects, slugs, and other animals. His horny beak has been pushed off; his lips have stretched back farther and farther, till they now open right back as far as his flat little ear; and he is a gaping, wide-mouthed, leaping frog \*—

. . . . "Hoarse minstrel of a strain  
Aquatic, leaping lover of the rain;"

(7, Fig. 15), with teeth in the roof of his mouth. But perhaps his tongue is the most curious of all, for instead of being fixed at the back, and free in the front, as in most other animals, the root of it is fastened to the front of his lower jaw, and the tip lies back in his mouth, so that when he wishes to catch an insect he throws his tongue quickly forward, captures his prey on the sticky point, and flings it back down his throat.

So he hops about the summer long, if he can only escape from ducks and rats and other frog-eating animals. He often takes to the water, for he can fill his lungs with air and use it very slowly, and, moreover, his soft skin is of great use to him in still breathing in the water or in the moist air; and when winter comes he takes refuge with many others at the bottom of the pond, and sinks into a state of torpor, till the spring brings croaking and egg-laying time round again.

Our little frog, then, is truly an animal with a double life, a genuine amphibian,† meaning by this, not merely an animal that can swim in the water and move on land, for seals and water-rats, white bears and hippopotamuses, can do this, but one that in the early part of its life would die if taken out of the water, while afterwards it lives and breathes in the air.

\* Not "waddling;" it is the toad, not the frog, that waddles.

† *Amphi*, all around; *bios*, life.

Have these double-lived creatures, then, such a great advantage over real water animals, or how can we account for their having adopted this strange life? If we only look upon them as they are now, we can scarcely call them particularly successful, compared to other animals. For though there are plenty of them, yet they are comparatively small and insignificant; and when we find large ones

Fig. 16.



The Common Smooth Newt \*—male and young in the water ;  
female on the bank.

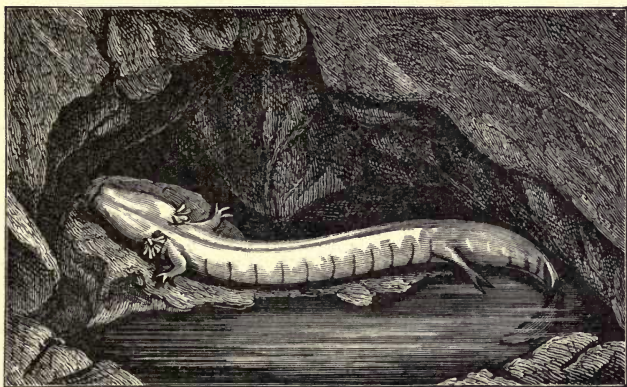
like the gigantic salamander of Japan, they are sluggish and feeble. Look at the common newts, or water-salamanders of our ponds, with their weak crawling limbs, as they wander round the edges of a pond, feeding on water-insects and tadpoles, the

\* *Lissotriton punctatus*.



male with his crested back, the smooth mother, and the young eft-tadpole with its branching tufted gills (Fig. 16). They are much less active than the frog, for they never lose their tails, and they come less often out of the water, although they are true air-breathing animals. Then, when we go to other countries, there is the Proteus (Fig. 17), that curious half-transparent newt, with a round body and tiny helpless legs, which lives in eternal darkness in

Fig. 17.



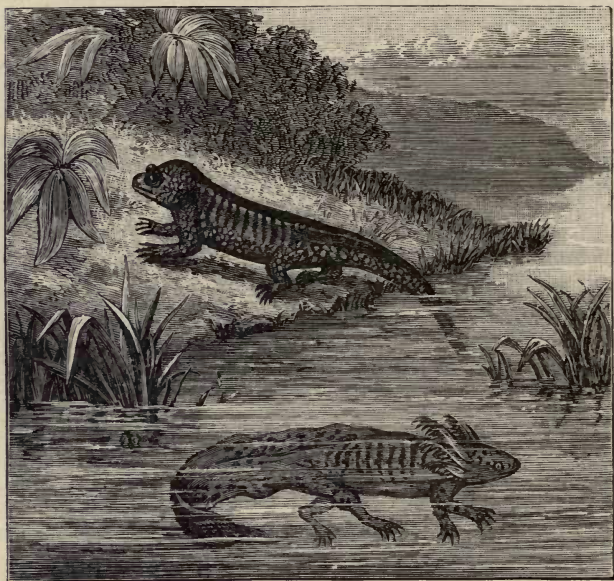
Proteus of the Carniola caverns,\* with its external breathing gills.—  
(Adapted from Brehm.)

the still underground pools of the Carniola caverns near Adelsberg. He has become well fitted for his dismal life, for his tiny eyes are grown over with skin, and he never loses the feathery gills on each side of his neck, but lives like a tadpole all his life, although he has true lungs. Again, in America we

\* *Proteus anguineus*.

have the Siren, with its long snake-like body, and only front legs, with which it cannot walk. It, too, keeps its gills as it wanders about the stagnant waters of South Carolina, feeding on worms and insects. Then in the Mexican lakes there are the curious Axolotls, which also wear outside gills, as a

Fig. 18.



Axolotl, a creature living and breeding for generations in the water. *Amblystoma* coming out of the water,—an axolotl which has lost the gills and acquired lungs.

rule, all their lives, and fathers, mothers, and children remain breathing in the water together, although they have real lungs. But about twenty years ago, some of those axolotls, which were kept in the Jardin

des Plantes in Paris lost their gills, came out upon the land, and astonished people by becoming true land salamanders, like some already well known and called Amblystomes, breathing only with their lungs. It was difficult for some time to make the world believe that grown-up water-breathing creatures which could lay eggs were able to turn into other creatures without gills. But at last a lady, Fraulein Marie von Chauvin, took some axolotls when they were full-grown, and kept them on land in wet moss, washing and feeding them every day, and thus succeeded in teaching them to breathe air, so that their gills shrivelled up and disappeared. Then there could no longer be any doubt that the axolotl is only the lower water-form of the amblystoma, which in the Mexican lakes, owing to the increased dryness of the surrounding country, has lost the habit of coming out on to the land, and remains in the water with its little ones all its life ; but which, when brought to a moist climate where it can breathe comfortably on land, sometimes returns to its old double life.

We have, in fact, in Europe real land salamanders, which live in cool damp places, looking like lumpy soft-skinned lizards, but going down to the water to lay their eggs, that their little ones may go through their tadpole life—and one of these, the black salamander,\* which lives high up in the mountains of Germany, France, and Switzerland, does not even go to the water, but carries the young tadpoles in her body till they can breathe air and run alone ; and yet they are still true *amphibia*, for if they are taken out of their mother and put in water, they

\* *Salamandra atra*.



go through all their changes like common efts and newts.

Lastly, there is a strange group of legless creatures called Cæcilians, which have taken refuge underground, burrowing like worms, though they are true amphibians and their young have gills in their babyhood hidden under a slit in the neck. These cæcilians are the only amphibians which have scales something like fishes, yet they never live in the water, but in the marshy ground of tropical countries, feeding on worms and insects.

Now when we think that these sluggish newts, and salamanders, and cæcilians, with their more nimble but comparatively unprotected relations, the frogs, are all the amphibians now living, we cannot but wonder how Life came to produce such a feeble set of creatures to fight the battle of existence.

But if we glance back to that far-off time when the ancient fishes were wandering round the shores and in the streams of the coal-forests, we shall be better able to read the riddle. For in those days it was a great step for an animal to get out of the water at all, and those that did so had a much better time of it than our frogs and newts have now, when the country is full of land enemies.

And so we find that the *amphibia* were not then the small scattered groups they are now, but strong lusty animals, with formidable weapons. In the hardened mud, which in those days formed the soft swampy ground of the coal-forests, but is now stiffened into the roofs and floors of our coal-mines, footprints have been left which tell us of large and



formidable creeping animals, with toed feet and long flat tails, dragging themselves over the marshes of the coal-forests, and finding their way to many places which even the mud-fish with their paddles could not reach ; and from time to time, in these same roofs and floors of our mines, both here and in America, we find the bones and coverings of these *amphibia*, buried in Nature's catacombs for ages, and only brought to light by the rude hand of man.

These remains remind us that

“A monstrous eft was of old the lord and master of earth,  
For him did the high sun flame, and his river billowing ran,  
And he felt himself in his force to be Nature's crowning race ;”

for they show us huge and powerful creatures \* which sported in the water or wandered over the land with sprawling limbs, long tails, and bones on which gills grew, while their heads were covered with hard bony plates, and their teeth were large, with folds of hard enamel on the surface. Some of these were fish-like, with short necks and broad flat tails, but they had true legs and toes ; others, more like crocodiles, and sometimes ten feet long, were able to walk firmly, but still dragging their bodies and long tails over the swampy ground on which their footprints are still found ; some were small and more like lizards, with simple teeth, scaly armour, and light nimble bodies ; and these, probably, ran about quickly on the land, and have sometimes left their skeletons in the hollow trunks of the old coal-forest trees.

All these plated and formidable creatures were *amphibia* or double-lived animals, and this was *their* Golden Age, as they preyed upon the fishes in the

\* See Picture-heading, p. 70.

swamps and ponds, probably not sparing even their nearest connections, the mud-fishes, who, less fortunate than themselves, had followed the road of fish-life instead of coming out upon the land. They lived so long ago that we can tell but little of their daily lives, but it is clear that they played a very different part from our small frogs and newts of to-day, and in their well-formed limbs were worthy forerunners of land and air-breathing animals.

But like the old race of fishes these large amphibians were only to have their day, for as other branches of the family tree grew up, and reptiles grew strong and mighty, and other true land animals began to flourish, these huge plated forms dwindled away, and we lose sight of them; and when we find any of their relations again it is only as our present frogs and newts, salamanders and cæcilians, which have taken up their refuge in lakes, ponds, ditches, underground waters, or damp mud. And, curiously enough, those forms of to-day which are most like the huge *Labyrinthodonts*,\* as they are called, of the old coal-forests, are the feeble cæcilians, with their horny scales and their numerous ribs, although they have now fallen the lowest of all amphibians, and, with their sightless eyes and ringed and legless bodies, have taken to burrowing in the ground like worms.

Not so the frogs, which, like the bony fishes, began their career in later times, and have known how to fit themselves into many nooks and corners in life. In almost all countries of the globe they hop merrily about the ponds and ditches, never wandering far from the water, into which they

\* *Labyrinthodonts* (*Laburinthos*, spiral; *odontas*, teeth).

jump and dive whenever danger threatens. It is true they are eaten by thousands, both as tadpoles and frogs, by birds, snakes, water-rats, and fish, and even by each other, but they multiply fast enough to keep up the supply, and find plenty of insects both in and out of the ponds. Nor have they kept entirely to a watery life, for their near relations, the toads, which have toothless mouths and toes less webbed, have ventured much farther on to the land, protected partly, no doubt, by the disagreeable acrid juice which they can throw out from a gland behind the eye whenever they are attacked.

It is curious to notice the quiet leisurely waddle of the sluggish toad, as he spreads out his short fat legs and puffs out his warty skin, and to compare him with the nervous, anxious, little frog, starting at every danger. And still more curious is it to see him getting out of his skin, as he does several times a year. For his skin does not peel off in pieces as it does in the watery frogs, but splits along his back ; then he wriggles about till it lies in folds on his sides and hips, and, putting one of his hind feet between the front ones, draws the skin off the leg like a stocking off a foot. With the other leg he does the same, and then, drawing out his front legs, pulls the whole skin forward, and stripping it over his head, swallows it ; thus deliberately putting his old coat inside him, and appearing in one that is glossy, fresh, and new. The toad has many enemies in spite of his acrid taste, and he shows his wisdom by hiding in walls and under stones in the daytime, and coming out in the dusk of evening to hunt the beetles and grubs so often out of reach of the water-loving frog.

But the toad is not the only land relation of the frog ; there are others of the group that venture even farther from water ; for in most parts of the world (though not in England), tree-frogs, with sucking disks

Fig. 19.



The Flying Tree-Frog of New Guinea \* (*Wallace*).

at the ends of their toes and fingers, climb the trees and hunt for insects among the leaves and branches ; while in Borneo Mr. Wallace found one (Fig. 19) with

\* *Rhacophorus Rheinhardti*.



webbed feet, which it spread out, and so flew down from the trees. There are plenty of the ordinary tree-climbing frogs to be seen in the south of France, their small green bodies peeping out from under the dull gray olive-leaves; and to be heard, too, in an endless chorus all night long when the spring arrives.

But how can these tree-dwellers bring up their little ones in water? Some of them come down and lay their eggs in the ponds, and even sleep down in the mud in winter. Others lay their eggs in little puddles of water in the hollows of the trees, and there the young ones live their tadpole life; while in one curious tree-frog of Mexico, called the *Nototrema*, the mother has a pouch in her back, and the father places the eggs in it for the little tadpoles to live in a moist home till they leap out as perfect frogs.

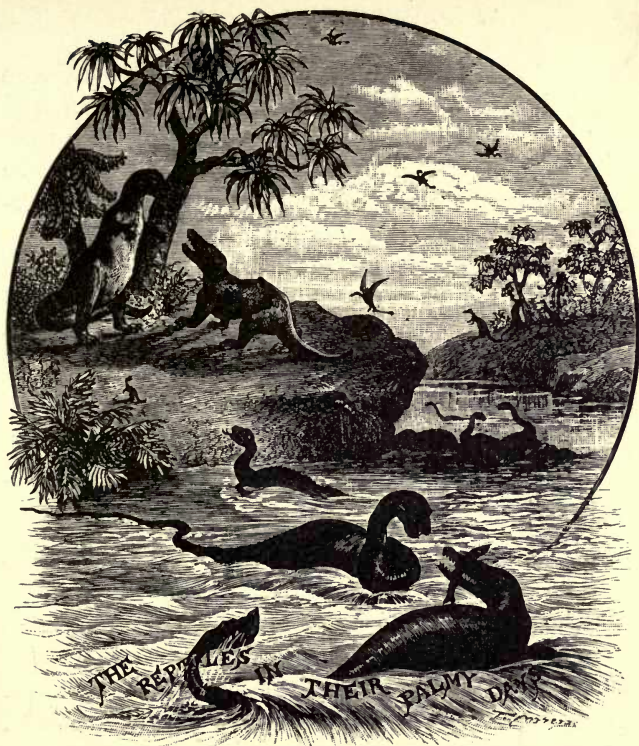
Nor is this the only case in which fathers and mothers take care of their young. In one species of frogs living near Paris, the father\* winds the long string of gluey eggs round his thighs, and buries himself in the ground till the young tadpoles are ready to come out, and then he leaps into the water. And in one of the tongueless toads, the Surinam toad,† the mother's soft skin swells up, forming ridges and hollows, and when her eggs are laid the father clasps them in his feet, and, leaping on her back, puts an egg into each hollow. Then the mother goes into the water, and remains there while each tadpole completes its changes in its own hole, jumping out at last a finished toad.

Yet, in spite of curious habits such as these, the frogs and their companions on the whole lead

\* *Alytes obstetricus*.

† *Pipa Americana*.

a very monotonous life. They are, it is true, more intelligent than fish, and have learned to know more of the world, but in the long ages that have passed since their ancestors roamed in the coal-forest marshes, other and higher animals have taken possession of the land, and left room only for a few scattered groups of *amphibia*. Still, however, they remain hovering between two lives, and filling such spots as neither the fishes nor the land animals can occupy; and when we hear them croaking in the quiet night, or see them leaping on the marshy ground, they remind us that we have still living in our day, a link between the fish whose world is a world of waters, and the air-breathing animals which have become masters of the land.



## CHAPTER V.

THE COLD-BLOODED AIR-BREATHERS OF THE GLOBE  
IN TIMES BOTH PAST AND PRESENT.

AND now the transformation is complete, for when we pass on to the next division of backboneed animals, the "Reptiles," we hear nothing more of gills, nor air taken from the water, nor fins, nor fishes' tails. From this time onward all the animals

we shall study live with their heads in the air, even if their bodies may be in the water; they swim with their legs or, as in the case of the snakes, with their wriggling bodies, and they lay their eggs on the land where their young begin life at once as air-breathers.

Yet they can often remain for a long time both under water and under ground, for they are still cold-blooded animals, breathing very slowly, and easily falling into a state of torpor when the air around them is cold and chill. They are but the first step, as it were, to active land-animals; yet they have played a great part in the world, and when we know their history we shall be surprised to find how much Life has been able to make of her cold-blooded children.

To learn how this has been, however, we must travel away from home and our own surroundings. The tiny brown lizard which runs over our heaths, while its legless relation, the slowworm, burrows in the ground,—the few snakes which glide through the grass of our meadows, and the stray turtles thrown at rare intervals on our shores,—tell us very little about true reptile life. It is to Africa, India, South America, and other warm countries, that we must go to find the formidable crocodiles, huge tortoises, large monitor-lizards, and dangerous boa-constrictors, cobras, and rattle-snakes. And even then, strong and powerful as some of these creatures are, they do not tell us half the history of the cold-blooded air-breathers. For the day of reptile greatness, like that of the sharks and enamel-scaled fish, was long long ago.



Now that we know how frogs pass from water-breathing to air-breathing, and how axolotls, accustomed to live all their life in the water, can lose their gills and become land-animals, we can form an idea how in those ancient days, while still the huge-plated newts were wandering in the marshes, some creatures which had lost their gills would take to the land, and their young ones starting at once as air-breathers, as the black salamanders do now (see p. 80), would in time lose all traces of the double or *amphibian* life, and become true air-breathing reptiles.

At any rate, there we find them appearing soon after the coal-forest period passed away, at first few and far between, in company with the large amphibians, but spreading more and more as the ages passed on, till they in their turn became monarchs of the globe. Already, when the coal-forests had but just passed away, a lizard,\* in some points like the monitors that now wander on the banks of the Nile, was living among his humbler neighbours; and from that time onwards we find more and more reptiles, till just before the time when our white chalk was being formed by the tiny slime-animals at the bottom of the sea, we should have seen strange sights if we could have been upon the globe. For the great eft was no longer

“ . . . . . lord and master of earth.”

All over the world, and even in our own little England, which was then part of a great continent, cold-blooded reptiles of all sizes, from lizards a few inches long to monsters measuring fifty or sixty feet from head to tail, swarmed upon the land, in the

\* *Protosaurus* or Thuringian lizard.

water, and in the air. There were among them a few kinds something like our tortoises, lizards, and crocodiles; but the greater number were forms which have quite died out since birds and beasts have spread over the earth, and a wonderful and powerful set they were.

Some were vegetable-feeders, which browsed upon the trees or fed upon the water-weeds, as our elephants and giraffes, our hippopotamuses and sea-cows do now. Others were ferocious animal-eaters, and their large pointed teeth made havoc among their reptile companions, as lions and tigers do among beasts. Some swam in the water devouring the fish, while others, like birds or bats, soared in the air.

In the open ocean were the sea-lizards, some called Fish-Lizards,\* like huge porpoises thirty feet long, but really cold-blooded reptiles, with paddles for legs, and long flattened tails for swimming. Woe to the heavily-enamel-scaled fish when these monsters came along, their pointed teeth hanging in their widely-gaping mouths as they raised their huge heads, with large open eyes, out of the water! Then among these were others with long swan-like necks and small heads,† which would strike at the fish below them in the water, while other slender, long-bodied monsters,‡ measuring more than seventy feet from tip to tail, flapped along the sea-shore with their four large paddles, or swam out to sea like veritable sea-serpents, devouring all that came in their way. These were all water-reptiles, while there were also many smaller land-lizards playing about

\* Ichthyosaurus. † Plesiosaurus. ‡ Mosasaurus and Clidastes.

upon the shore, and among the trees and bushes. But the strangest of all were perhaps the "Flying reptiles" \* of all sizes, from one as small as a sparrow to one which measured twenty-five feet from tip to tip of its wings. These reptiles did not fly like birds, for they had no feathers, but only a broad membrane, stretching from the fifth finger of their front claw to their body, and with this they must have flown much as bats do now, while some of them were armed not only with claws, but also with hooked beaks and sharp teeth, with which they could tear their prey.

And meanwhile upon the land were wandering huge creatures, larger than any animal now living, which were true reptiles with teeth in their mouths, yet they walked on their hind legs like birds, probably only touching the ground with their short front feet from time to time, as kangaroos do. They had strong feet with claws, the marks of which they have left in the ground over which they wandered, supporting themselves by their powerful tails as they went.

Some of them were peaceful vegetarians,† browsing on the tree-ferns and palms, and rearing their huge bodies to tear the leaves from the tall pine-trees. But others were fierce animal-feeders. Fancy a monster thirty feet high,‡ with a head four or five feet long, and a mouth armed with sabre-like teeth, standing upon its hind legs and attacking other creatures smaller than itself, or preying upon those other huge reptiles which were feeding peacefully

\* Pterodactyls. † Iguanodon in Europe, Hadrosaurus in America.

‡ Megalosaurus in Europe, Dryptosaurus in America.

among the trees. Surely a battle between a lion and an elephant now would count as nothing compared to the reptile-fights which must have taken place on those vast American lands of the west, or on the European pasture-grounds, where now the remains of these monsters are found.

But where are they all gone? We know that they have lived, for we can put together the huge joints of their backbones, restore their gigantic limbs, and measure their formidable teeth, but they themselves have vanished like a dream. As time went on, other and more modern forms, the ancestors of our tortoises, lizards, crocodiles, and afterwards snakes, began to take the place of these gigantic types ; while warm-blooded animals, birds and beasts, began to increase upon the earth. Whether it was that food became scarce for these enormous reptiles, or whether the birds and beasts drove them from their haunts, we are not yet able to find out. At any rate they disappeared, as the ancient enamelled fishes and large newts had disappeared before them, and soon after the beds of white chalk were formed, which now border the south of England and north of France, only the four divisions of tortoises, lizards, crocodiles, and snakes, survived as remnants of the great army of reptiles which once covered the earth.

Ah ! if we could only have a whole book upon reptiles to show how strangely different these four remaining groups have become during the long ages that they have been using different means of defence ; and how, even in a single group, they employ so many varied stratagems to survive in the



battle of life! Look at the tortoises with their hard impregnable shells, the crocodiles with their sharp-pointed teeth and tough armour-plated skins, and the silently-gliding snakes with their poisonous fangs or powerful crushing coils. See how the tiny-scaled lizard darts out upon an insect and is gone in the twinkling of an eye, and then watch the solemn chamæleon trusting to his dusky colour for protection, and scarcely putting one foot before another in the space of a minute.

Each of these has his own special device for escaping the dangers of life and attacking other animals, and yet we shall find, before we finish this chapter, that they are all formed on one plan, and that it is in adapting themselves to their different positions in life that they have become so unlike each other.

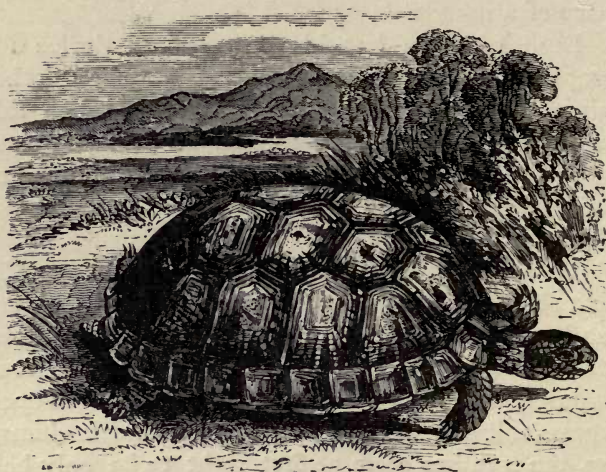
We shall all allow that the Tortoises are the most singular of any, and it is curious that they are also in many ways the nearest to the frogs and newts, although they are true reptiles. Slow ponderous creatures, with hard bony heads (Fig. 20), wide-open expressionless eyes, horny beaks, and thick clumsy legs, the tortoises seem at first sight to be only half alive, as they lumber along,

“ Moving their feet in a deliberate measure  
Over the turf,”

carrying their heavy shell, and eating, when they do eat, in a dull listless kind of way. They do, in truth, live very feebly, for they can only fill their lungs with air by taking it in at the nostrils and swallowing it as frogs do, and then letting it drift out again as the lungs collapse, for their hard shell prevents them from

pumping it in and out by the movement of their ribs like other reptiles. This slowness of breathing and the fact that they have only three-chambered hearts like frogs (see p. 76), so that the good and bad blood mix at every round, causes them to be very inactive, and they digest their food very slowly, and have been known to live months and even years without eating.

Fig. 20.



The Greek Tortoise.

This sluggishness would, indeed, certainly be their ruin in a bustling greedy world, if it were not for the strong box in which they live. Take in your hand one of the small Greek\* or American† tortoises, so often sold as pets, and you will see how well he can draw back out of harm's way, while at

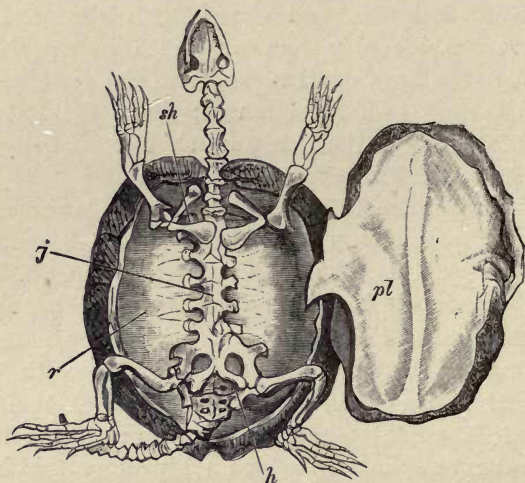
\* *Testudo Græca*.† *Testudo talenlata*.

the same time you will, I think, be sorely puzzled to understand how he is made. His head, his four legs, and his tail, with their thick scaly skin, are intelligible enough. But why do all these grow on to the inside of his shell, so that when you trace them up you cannot find the rest of his soft body? You would hardly guess that his shell *is* the rest of his body, or at least of his skeleton. But it is so. The arched dome which covers his back is made of his backbone and ribs, and the shelly plates arranged over it are his skin hardened into horny shields, which, in the Hawksbill turtle, form the tortoise-shell which is peeled off for our use; while the flat shell under his body is the hardened skin of his belly, and the bones which belong to it.

Let us make this clear, for it is a strange history. If you look at the skeleton of a lizard (Fig. 23, p. 103), it is all straight-forward enough. His head fits on to his long-jointed backbone, which is able to bend in all parts freely, down to the very tip of his tail. His front legs with their shoulder bones (*s*), and his hind legs with their hip bones (*h*), are attached in their proper places to his backbone, and lastly, his ribs (*r*) protect the inside of his body, and by expanding and contracting pump the air in and out of his lungs, the front ribs being joined underneath in a breastbone. It is easy to see, therefore, that the lizard may be active and nimble, twisting his body hither and thither, and escaping his enemies by his quickness. But the tortoise is slow and sluggish, and has only managed to baffle the numberless animals which are looking out for a meal by fabricating a strong box to live

in. But he had to make this out of the same kind of skeleton as the lizard, with the one difference that he has no breastbone. Let us see how it has been brought about. The bones of his neck are jointed and free enough as you can see (Fig. 21), and so are the joints of his tail, beginning from behind his hip bones (*h*). But with his back it is different. The

Fig. 21.



Carapace of the Tortoise.

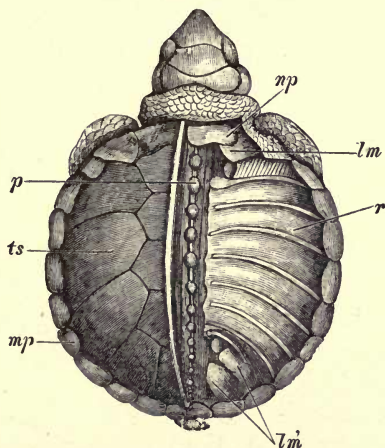
*j*, Joints of the backbone grown together ; *r*, ribs formed into a solid cover ; *sh*, shoulder bones ; *h*, hip bones covered by carapace, which has grown over them.

backbone can be clearly seen inside the empty shell, running from head to tail so as to cover the nerve-telegraph, but the joints (*j*) have all grown together, and on the top they have become flattened into hard



plates,\* while the ribs (*r*) which are joined to them have also been flattened out and have grown firmly together so as to make an arched cover or *carapace*. If now you look at the back of the young tortoise (Fig. 22), which has been taken out of the egg before it was full-grown, you will see these plates (*p*) on the

Fig. 22.



Back of a Young Tortoise.—(From Rathke.)

*ts*, Tortoise-shell covering the whole carapace; this has been removed on the right side; *mp*, marginal plates binding the edges of the ribs; *np*, neck-plate; *p*, plates formed of the top of the backbone joints which have grown together; *r*, ribs which have not yet spread out so as to form a continuous shell; *lm*, *lm'*, front and hind leg muscles not yet covered by the carapace.

side where the tortoise-shell (*ts*) has been peeled off. They have not yet widened out enough to be joined together, and the ribs (*r*) are as yet only united by

\* The parts of the joints which flatten out in the tortoise are seen at *sp* in the lizard and snake, pp. 103, 111.

strong gristle. But what is that row of oblong plates (*mp*) round the edge? Those are the marginal plates, and they are mere skin bones, like the bony plates of the crocodile, but they are all firmly fixed together so as to bind the edges of the ribs, while plates of the same kind form the shell under the body, and the whole is covered by the horny skin.

But there still remains another great puzzle. How come the shoulder bones and hip bones of the tortoise to be inside his ribs instead of being outside them, as in other animals? But look again at our baby tortoise, and you will see that the muscles of his front legs (*lm*, Fig. 22) are not covered by ribs, neither are those of his hind legs (*lm'*). They stand just like those of other animals, in front between the ribs and the neck, and behind between the ribs and the tail. But as the tortoise grows up, the bony plates press forwards and backwards, and cover up the shoulders and hips, protecting the soft legs and neck, and giving him the curious appearance of living inside his own backbone and ribs.

In this way, then, the tortoises have managed to hold their own in the world. Living slowly, so that they sometimes go on growing up to eighty years old, wanting but little food, and escaping the cold by sleeping the winter months away in some sheltered nook, they ask but little from Life, while they escape the dangers of sluggishness by growing their skeletons so as to form a citadel which even birds and beasts of prey can rarely break through. They are, it is true, often eaten when young, and the jaguar of Brazil knows how to dig the poor American tortoise out of his shell and eat him; while

large birds are formidable enemies to our Greek tortoise, and are said to drop it down on the rocks, and break it to pieces. But, on the whole, they escape most of these dangers, and wander in the woods and dry sandy places of sunny Greece and Palestine, laying their bullet-shaped eggs in warm spots to hatch, seldom wandering far from home, and lying down for their winter's sleep under heaps of drifted leaves or in holes of the ground.

These are true Land-tortoises,\* and so are the gigantic tortoises which used to live in the island of Aldabra, and other islands near Madagascar, and others still surviving in the Galapagos, which weigh at least 200 pounds, and on whose backs Mr. Darwin rode when he found them travelling up the island to get water to drink, feeding on the juicy cactus as they went. Some carapaces in our museums belonging to these tortoises measure four feet long and three broad; yet they were timid fellows when alive, drawing back completely within their shells when danger was near. We even find some smaller land-tortoises † in America, called the Box-tortoises, which have soft joints in their under shell, so that they can draw it up both in front and behind, shutting themselves completely in.

Not so the River-tortoises, ‡ which are greedy animal-feeders, and as they live in the water do not need the same protection. Their box is much flatter and more open at the ends, so as to allow them to swim freely with their webbed feet; and they are fierce and bold, the Snapping Turtle§ of the lakes and

\* Testudinea.

† Terrapins.

‡ Emyx and Trionys.

§ Chelydra serpentina.

rivers of America being a terrible fellow, tearing the frogs and fishes in the water with his sharp claws, and even snapping strong sticks in half with his powerful beak. The Mud-tortoises, too, which swim swiftly with their strong legs and long neck outstretched, do not need a hard shell, and they have scarcely any plate below, and only a gristly leathery covering above, which looks very like the mud in which they hide.

Lastly the Sea-tortoises or Turtles, which swim in the warm parts of the Atlantic and Pacific Oceans, have only an open flat shell under which they cannot draw their head and feet, for they strike out boldly into the open ocean, feeding on sea-weed, jelly-fish, and cuttle-fish, rowing grandly along with their broad paddles which they feather like oars as they go. They have only one time of weakness—when they come on islands, such as Ascension and the Bahama Islands, which they choose probably because they find fewer large animals there. There the mother turtle arrives at night, looking fearfully around, and if all is still comes flapping in over the sand, and, clearing a hole with her flippers, lays about 200 soft round eggs and covers them up and leaves them. Then in about a month the young turtles come out and make at once for sea, though many of them fall victims to large birds of prey on their way. Woe, too, to the mother when she is laying her eggs, if these large birds are near, for she cannot defend her soft body; or, worse still, if the natives are on the look-out; for then the Green Turtle,\* coming ashore from the Atlantic, is tilted over on her back and killed for food; and the Hawk's-bill Turtle † from the Indian or Pacific Oceans

\* *Chelonia midas*.

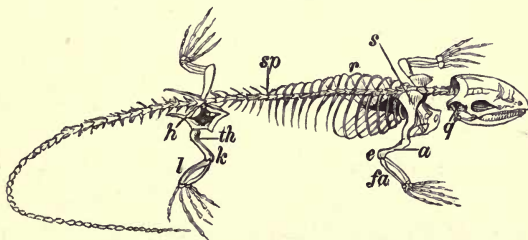
† *Chelonia imbricata*.



is cruelly stripped of its shell for ornaments. Yet they must run these risks, for their eggs would not hatch without the warm sun, and we see how great is the gap between the last water-breathers and the first air-breathers, when we remember that the frogs go back to lay their eggs in the water, while the tortoises, even when they live far out at sea, are forced to come in to shore, in spite of great dangers, to lay their eggs that their little ones may begin life upon land.

And now, if we leave the tortoises and turn to

Fig. 23.



Skeleton of a Lizard.

*sp*, Spinous processes, which in the tortoise are flattened into plates ; *r*, ribs ; *s*, shoulder bone ; *a*, upper arm ; *e*, elbow ; *fa*, forearm ; *h*, hip bone ; *th*, thigh bone ; *k*, knee ; *l*, bones of the leg ; *q*, quadrate bone between upper and lower jaw.

the Lizards, we find them meeting life's difficulties in quite a different way. Here are no sluggish movements, horny beaks, and strong boxes ; but bright-eyed creatures covered with shining scales, their mouths filled with sharp teeth, with which even the small lizards can bite fiercely, and having nimble lissome bodies, which wriggle through the grass or up the trees in the twinkling of an eye. Yet the lizards, as we have

seen, are formed on the same plan as the tortoise, and their scales are thickenings in their outer skin, just as his tortoise-shell is, and not true scales like those of fish. They have learned to hold their own by sharpness and quickness, and are probably the most intelligent of all the cold-blooded animals, though even they are only lively in a jerky way under the influence of warmth. They can breathe more easily than the tortoise, for their ribs rise and fall, drawing in and driving out the air they need ; but they are still cold-blooded, for their heart has only three chambers. It is when the bright sun is shining that they love to dart about, chasing the insects upon which they feed ; and the joints of their backbone move so easily upon each other that they can twist and turn in all imaginable ways, keeping their heads twisted in a most comical manner when on the watch for flies. Nay, the very vertebræ themselves are so loosely made that they can split in half, and if you seize a lizard by the tail he will most likely leave it in your hand and grow another.

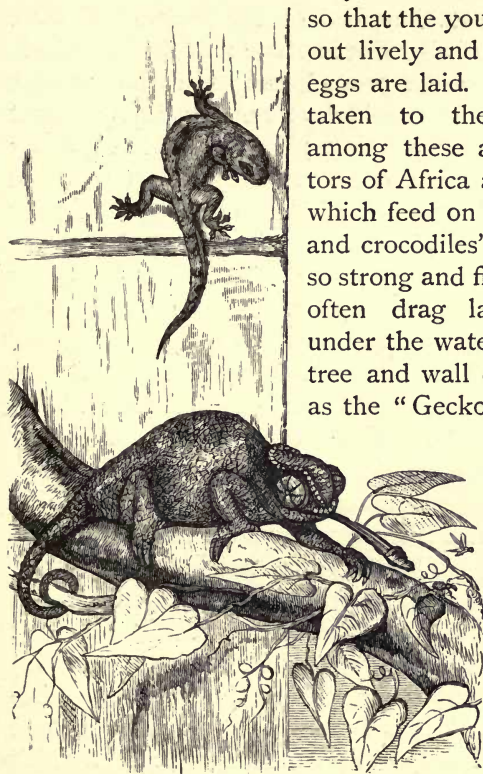
They can live both in dry sandy places, where larger animals cannot find food and water, and in thick underwood, and marshy unhealthy places, where more quickly-breathing animals would be poisoned by the fetid air ; and we find them swarming in hot countries in spite of enemies, their scales protecting them from the rough surface of the rocks and trees on which they glide, their feeble legs scarcely ever lifting their body from the object on which they glide rather than walk.

The true land-creeper, like our little Scaly Lizard,\*

\* *Zootoca vivipara*.

lurk in dry woody places, and on heaths and banks, darting out on the unwary insects. Many of them lay their eggs in the warm sand or earth, but the

Fig. 24.



Gecko and Chamæleon.

Scaly lizard carries them till they are ready to break, so that the young ones come out lively and active as the eggs are laid. Others have taken to the water, and among these are the Monitors of Africa and Australia, which feed on frogs and fish and crocodiles' eggs, and are so strong and fierce that they often drag larger animals under the water. Some are tree and wall climbers, such as the "Geckos," with thick

tongues and dull mottled skins, and they have sharp claws and suckers under their toes, so that they can hang or walk upside down, on ceilings or overhanging

rocks, or on the smooth trunks of trees; and they love to chase the insects in the hot sultry nights,

tracking them to their secret haunts. They are far more active than the large gentle Iguanas or Tree-Lizards of South America, from a few inches to five feet long, which may be seen among the branches of the trees of Mexico, their beautiful scales glistening in the sun as they feed on the flowers and fruit. They swarm on all sides in those rich forest regions, scampering over the ground, and then clinging with their claws to the tree-bark as they gradually mount up into the dense foliage; and they have many advantages, for not only can they climb to great heights out of the reach of beasts of prey, but they can also swim well, having been known to fling themselves from the overhanging branches into the water below when danger was near. They do not, moreover, descend as gracefully as the "Flying Lizards" of the East Indies, which have a fold of skin stretched from the lengthened ends of their hinder ribs, so that they sail from branch to branch as they chase the butterflies and other insects.

But the most curious of all tree-lizards is the Chamæleon, with his soft warty skin, his round skin-encircled eyes, his birdlike feet, and his clinging tail. He never hurries himself, but putting forward a leg, at the end of which is a foot whose claws are divided into two bundles, he very deliberately grasps the branch, as a parrot does, loosens his tail, draws himself forward, and then fastens on again with tail and claws; while his eyes, each peering out of a thick covering skin, roll round quite independently of each other, one looking steadily to the right, while the other may be making a journey to the left. What is he looking for? Just ahead of him on a twig sits a fly;



but he cannot reach him yet. So once more a leg comes out, and his body is drawn gradually forwards. Snap! In a moment his mouth has opened, his tube-like tongue, with clubbed and sticky tip, has darted out and struck the fly, and carried it down his throat, while the chamæleon looks as if he had never moved. It is not difficult to imagine that such a slow-moving animal, whose natural colour is a brownish green like the leaves among which he moves, would often escape unseen from his enemies. And when light falls upon him, his tint changes by the movement of the colour-cells in his skin, which seem to vary according to the colour of the objects around, whenever he is awake and can see them.

So by the waterside, on the land, and among the trees, the lizard tribe still flourish in spite of higher animals; and just as we found some legless kinds among the *amphibia* burrowing in the ground, so here, too, we find legless lizards, some with small scaly spikes in the place of hind legs, others, like the glass-snake of America\* and our English slowworm† (or blindworm), which have no trace of feet outside the skin, but glide along under grass and leaves, eating slugs and other small creatures, though they are true lizards with shoulder bones and breastbones under the skin.

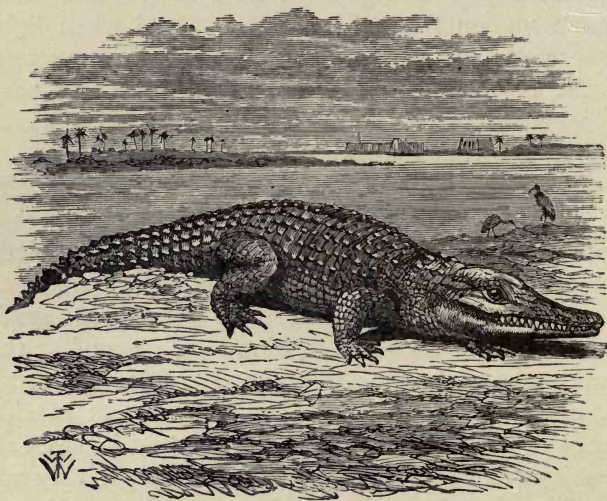
Here, then, we seem to be drifting along the road to snake-life, but we must halt and travel first in another direction, upwards to a higher group of animals, which may almost be called gigantic flesh-eating lizards, though they are far more formidable

\* *Ophisaurus ventralis*.

† *Anguis fragilis*.

and highly-organised creatures. These are the Crocodiles, and no one looking at them can doubt for a moment that they at least are well armed, so as to have an easy time of it without much exertion. Huge creatures, often more than twenty feet long, with enormous heads and wide-opening mouths, holding more than thirty teeth in each jaw, they look

Fig. 25.

The Nile Crocodile.—(*Tristram.*)

formidable indeed as they drag their heavy bodies along the muddy banks of the Nile, their legs not being strong enough to lift them from the ground. Their whole body is covered with strong horny shields, and under these shields, on the back, are thick bony plates, which will turn even a bullet aside, and quite protect the crocodile from the fangs of

wild beasts. Their eyelids are thick and strong, and they have a third skin which they can draw over the eye sideways like birds ; their ears, too, have flaps to cover them, and their teeth are stronger and more perfect than any we have yet seen, for they are set in sockets, and new ones grow up inside the lower part of the old ones as they are broken or worn away.

But it is in the water that we see them in their full strength ; there they swim with their webbed feet and strokes of their powerful tail, and feed upon the fishes and water animals—monarchs of all they survey. Nor is the crocodile content with mere fish-diet. Often he will lie with his nostrils just above the water and wait till some animal—it may be a goat, or a hog, or even a good-sized calf—comes to drink, then he will come up slowly towards it, seize it in his formidable jaws, or sometimes strike it with his powerful tail, and drag it under water to drown. For he himself can shut down his eyelids and the flaps over his ears, and he has a valve in the back of his throat which he can close, and prevent the water rushing down his open mouth ; and after a while he rises slowly till his nostrils are just above the water, and he can breathe freely while his victim is drowning, because his nose-holes are very far back behind the valve. Then when it is dead he brings it to shore to tear it to pieces and eat it.

Thus the crocodiles of the Nile and the Ganges, the Gavials with their long narrow snouts, and the Alligators of America, with their shorter and broader heads, feed on fish and beasts, and all dead and putrid matter, acting as scavengers of the rivers ; while they themselves are almost free from attack,

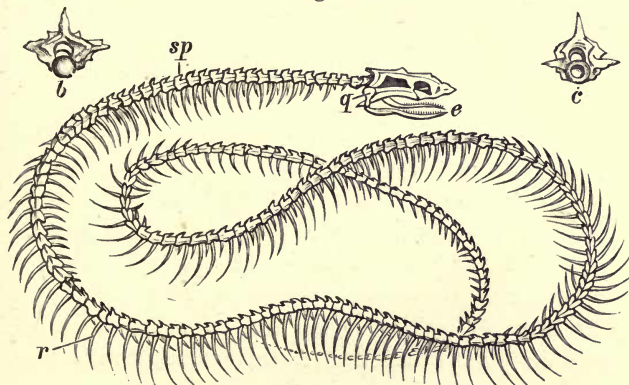
except when tigers fall upon them on land. But it is the young crocodiles which run the most risks when they come out of the small chalky eggs which have been hatched in the warm sand of the shore. True, their mother often watches over them at this time, and even feeds them from her own mouth ; but in spite of her care many of them are eaten in their youth by the tortoises and fishes which they would themselves have devoured by-and-by, if they had lived to grow up ; while the monitors, ichneumons, waterfowl, and even monkeys, devour large numbers of crocodiles' eggs.

And now, if we were to turn our backs upon the great rivers in which these animals dwell, and wander into the Indian jungle or the South American forest, we might meet with enemies far more dangerous and deadly, although they stand much lower in the reptile world. Who would think that the huge boa of South America, and the python and poisonous cobra of India, or even our own little viper, whose bite is often death to its victim, are creatures of lower structure than the harmless little lizard or the stupid alligator ? Yet so it is. For Snakes have no breastbone and have lost all vestiges of front legs and shoulder bones, nor have they any hips or hind legs except among the boas and rock-snakes ; and even these have only small traces of hips, which carry some crooked bones, ending in horny or fleshy claws, in the place where hind legs ought to be. They have no eyelids (and by this we may know them from the legless lizards), but their skin grows right over the eyes, so that when a snake casts its skin there are



no holes where the eyes have been, but only clear round spaces like watch-glasses, in the scaly skin. Their ears have no drum, and are quite hidden under the scales with which their body is so thickly covered that they must feel very little as they glide along. These scales, like those of the lizard, are thickened parts of the outer skin, and if you stretch a piece of snake-skin you can see them lying embedded in it, the clear skin itself showing between.

Fig. 26.



Skeleton of a Snake.

*sp*, Spinous processes of the joints; *r*, ribs; *q*, quadrate bones, joining upper and lower jaws; *e*, front of the lower jaw, where there is an elastic band in the place of bone; *b*, ball end of joint, facing the tail; *c*, cup end of joint, facing the head.

We must not, however, imagine that the snake is at a disadvantage because he has lost so many parts which other reptiles possess. On the contrary, he has most probably lost them because he can do better without them. The transparent tough skin over his eye is a far better protection in narrow

rugged places, and among brakes and brambles, than a soft movable eyelid ; and if he does not see as well as the crocodile, he has a most delicate organ of touch in his long, narrow, forked tongue, with which he is constantly feeling as he goes, touching now on one side, now on the other, each object he comes near, and drawing the tongue in at every moment to moisten it in a sheath at the back of his throat. A breast bone, moreover, would have been a decided hindrance to him, for he wants the free use of all his ribs ; and as to the loss of his legs—in the place of four he has often more than two hundred. For all along his backbone, except just at the head and tail, a pair of ribs grow from each vertebra, being joined to it by a cup-and-ball joint (*c* and *b*, Fig. 26), and the muscles between them are so elastic that the ribs can be drawn out so that the body seems to swell, and then drawn back towards the tail. In doing this they strike the ground and the snake moves forwards, just as a centipede does on its hundred legs.

It is worth while to take our harmless Ringed Snake in your hand to feel this curious movement to and fro of the ribs, and to notice how the creature forces itself through your grasp. Moreover, you will learn at the same time one use of the broad single plates under the snake's body (see Fig. 27), for they, like all the scales, are loose from the skin on the side towards the tail ; and as they are fastened by muscles to the ends of the ribs, you will find that at each movement they stand up a little like tiles on a roof, and their edges coming against your hand help to drive the snake forward.

Another thing you will learn if the snake does

not know you, and that is how strangely they hiss, often with their mouth closed, while their whole body seems to quiver. This is very puzzling at first, till you learn that one of their lungs has shrunk up, and the other is a very long and narrow bag stretching nearly the whole length of the snake's stomach,

Fig. 27.



Common Ringed Snake.\*

Where the body is coiled the single under plates are seen.

and the hissing sound is made by drawing in and forcing out the air from this long bag.

Meanwhile, another way in which the snake will escape from your hold unless you grasp it tightly, is by wriggling in all directions, so that you do not know where to expect it next ; for the whole of the joints of

\* *Natrix torquata*.

its backbone are joined by a succession of cups-and-balls, the ball of one joint fitting into the cup in the one behind it. It is easy to see how such joints can move almost every way, since the ball can twist freely in the cup wherever the muscles pull it (except where checked by the spines on the top of the backbone), and can even turn so much to one side that the snake can coil itself round or tie itself into a knot.

A creature that can glide along so smoothly, twist about so freely round trees, through narrow openings and tangled brushwood, and even swim in the water, has no small advantage in life; and the snake can also coil itself up under a heap of dead leaves or in a hollow trunk of a tree for safety, or to watch for its prey when no animal would suspect it was near. But even the harmless snakes have something besides this, namely, the power of swallowing animals much broader and thicker than themselves. You will see on looking at the lizard's skull (p. 103) that its bottom jaw is not joined at once to the top one, but there is a bone (*q*) between, which enables it to open its mouth wider than if the two jaws touched each other. Now this bone (*q*) in the snake's jaw is so loosely hung that it moves very easily, and the lower jaw also stretches back far behind the upper one, so that when the snake brings the jaw forward it can open its mouth enormously wide. Nor is this all; it can actually stretch the bones of its jaws apart, for they have not their pieces all firmly fixed together. In the front of the mouth each jaw has elastic gristle in the place of bone, and the two halves of the jaw can thus be forced apart from each other, making room for a very large mouthful indeed.



Now the snake's teeth are all curved towards the back of his mouth, and they are never used for chewing or tearing, but only for holding and packing

Fig. 28.



The Boa Constrictor in the Forests of South America.

down its food. So when he seizes a creature too large to be easily swallowed, he fastens his front teeth into

it and then brings forward *one* side of his jaws. He then fixes the teeth of this side into the animal, and holds it fast while he brings forward the jaws on the *other* side, fixes these teeth, then loosens and brings forward the others, and so on. In this way he keeps his mouth stretched over the prey and gradually forces it down his elastic throat, moistening it well all the time with slime from two glands, one on each side of his mouth, and when it is swallowed he lies down and rests while the stomach digests its heavy load.

We see, then, that even harmless snakes have many advantages. Thus our ringed snake, feeding on mice and lizards, frogs and fish, wanders through the grass and bushes of warm sunny banks, feeling this side and that with his delicate forked tongue, and gliding so fast that the lizards and mice try in vain to escape; while in the water he seizes the frogs by their hind legs and jerks them into his mouth. He does not even always stop to kill his food, for a live frog has been known to jump out of a snake's mouth as it yawned after its meal. So he lives through the summer, changing his skin several times by loosening it first at the lips, so that two flaps lie back over the head and neck, and then rubbing himself through moss, bush, or bramble, so that the skin is drawn off inside out like a glove, and the new skin appears underneath, fresh, hard, and bright, ready for use. Then in the warm season the mother lays her ten or twenty soft eggs in a mass of slime, and leaves them in some sunny spot, or under a heap of warm manure to hatch, and she herself wanders away, and when winter comes coils herself up in the trunk of some hollow tree, or

under the hedge, to sleep till spring comes round again. Life does not always, however, flow so smoothly as this, for the snakes have their enemies; the fox and the hedgehog love to feed upon them, the buzzard and other birds of prey swoop down upon them from above, and the weasels attack them below; and this, perhaps, is partly the reason why the ringed snake generally keeps near the water, into which it can glide when danger threatens.

All snakes are not, however, so harmless as our little ringed snake. The Pythons of India and the Boas of America, though they have no poison in their teeth, can work terrible mischief with their powerful joints as they coil round even good-sized animals, such as an antelope or a wild boar, and crush them in their folds. Then it may be seen what a terrible weapon this flexible backbone is, as the muscles draw it tighter and tighter round the unfortunate animal, breaking its bones in pieces, till, when it is soft enough to be swallowed, the snake gradually forces it down its capacious mouth, moistening it with saliva as it goes. These large boas and pythons would, in fact, probably devastate whole countries if it were not that when they are young they are devoured by other animals, so that very few live to grow into dangerous marauders.

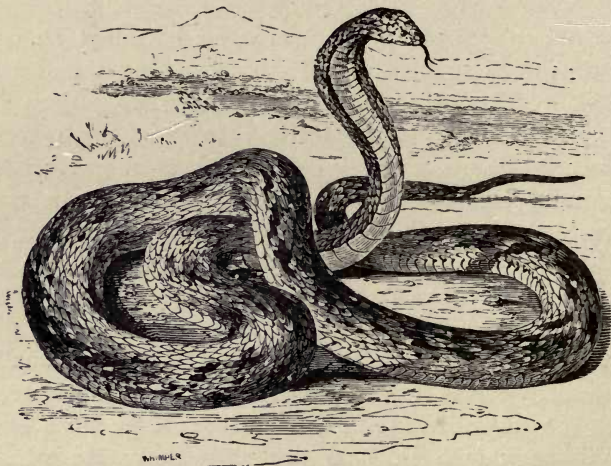
Other snakes have taken a still more terrible way of killing their prey. There may be some chance of escape from a coiling snake, unless he already holds you with his teeth, but the poisonous Cobra\* may strike before you know that you have startled him, and though the Rattlesnake† makes a sharp noise as he

\* *Naja*.

† *Crotalus*.

shakes the loose horny plates to call his mate or to alarm an enemy, yet when he means to strike his prey it is too late when the sound is heard to get out of reach of his fatal fangs. From the snake's point of view, however, it is clearly an advantage to be able with one single stroke to paralyse its prey, so that it has only to wait for the poison to do its work, and then

Fig. 29.



The Cobra di Capello.\*—(From Gosse.)

The mouth being closed, the poison fangs cannot be seen. The tongue is perfectly harmless.

its meal is ready. Even our little viper (see p. 121), needs only to strike a mouse once, and then draws back as the poor victim springs up and falls and dies, soon to be packed down its destroyer's throat.

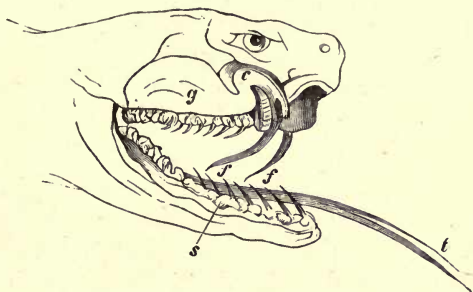
Yet this terrible poison, which acts so speedily, is no special gift to the snake. It has only lately been

\* Naja tripudians.



discovered by M. Gautier that we, and probably all animals, have in our saliva some of the very poison with which the cobra kills its prey, only with us it is extremely diluted, and is useful in digesting our food. The cobra, however, has the poison, which no doubt exists in the slimy saliva of all snakes, specially concentrated and collected in two glands, one on

Fig. 30.



Jaw of a Rattlesnake.

*ff.* Poison fangs; *g*, gland secreting poison; *c*, canal leading from gland to base of fang; *t*, harmless tongue; *s*, saliva glands.

each side of its jaw. From each of these glands (*g*) a small canal passes under the eye to the edge of the jaw (*c*), and opens immediately above a large curved fang (*f*). This fang is fastened to a bone in the cheek which moves easily, so that the poison teeth can be shut back and lie close against the gum when they are not wanted, and when they are wanted can be brought quickly down again. Though the fang looks round like ordinary teeth, it is really flattened out like a knife-blade, and then the edges are curved forwards so as to form a groove or, in some snakes, a closed tube, down which the poison can run to the point.

Now when the snake wishes to strike its prey it raises its head, brings down the fangs and drives them into the creature's flesh, and at the same time certain muscles press upon the poison gland, so that the liquid poison is forced into the wounds. If, however, the fang was fixed to the canal, the snake's weapon would be gone if the point were broken, so we find that the canal-opening lies just *above* the tube of the tooth, and behind are six small reserve teeth, covered by a tender sheath skin, ready to grow up and take its place when wanted.

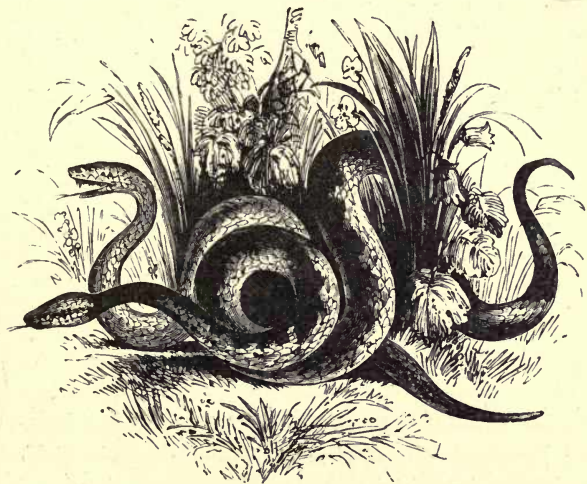
Should we not think that with such weapons as these the poisonous snakes would conquer every enemy? Yet they, too, only have their fair chance of life, for besides the destruction of their eggs other dangers await them. The rapacious birds, with their feathery covering, their horny and scale-covered legs and feet, and their hard beaks, will offer battle even to a poisonous snake. The buzzard makes short work of our common viper or adder, whose fangs, though fatal to small animals, are not nearly so powerful as those of snakes of hot countries. Seizing the viper with his claws in the middle of its body, the buzzard takes no notice of its frantic struggles as, winding itself about his feet, and striking wildly at his breast, his wings, and his scaly legs, it

“ . . . doth ever seek  
Upon its enemy's heart a mortal wound to wreak.”

Keeping his own head well back out of danger, the bird lets the snake exhaust itself, waiting only till he can give a fatal blow with his beak upon its upraised head, and then, soon despatching it, tears it to pieces for a meal. Nor is even the dreaded Cobra safe from

danger, for he finds his match in the powerful Adjutant birds (see p. 128), and in the Indian Ichneumon or Mungoos, which attacks the snake boldly, skilfully dodging the fatal stroke until it has broken the neck of its enemy ; while in Africa the bold Secretary bird is complete master of the dreaded poisonous snakes

Fig. 31.



Common English viper (*Peliobates*), with poison-fangs showing in the open mouth, and the soft harmless tongue outstretched to feel.

of that country. In fact, there is little doubt that every kind of snake, either in youth or age, falls a victim to some kind of bird or beast ; and even the poisonous sea-snakes, which swarm in the tropical seas, probably find their masters in the pugnacious saw-fish and the thick-skinned shark.

We see, then, that it is not without some struggle that these cold-blooded reptiles have held their own

in the world, nor is it to be wondered at that only these four types—tortoises, lizards, crocodiles, and snakes—should have managed to find room to live among the myriads of warm-blooded animals which have filled the earth. These four groups have made a good fight of it, and many of them even make use of warm-blooded animals as food. The tortoises, it is true, feed upon plants, except those that live in the fresh water, and feed chiefly on fish, snakes, and frogs, while most of the lizards are insect-feeders. But the crocodile, as he lurks near the river's edge, and the snake, when he fastens his glittering eye on a mouse or bird, are both on the look-out for animals higher in the world than themselves.

It is, perhaps, natural that we should shrink from cold-blooded creatures, especially as they *seem* to show very little affection. Yet lizards, tortoises, and snakes can all be made to know and care for those who are kind to them; while, as we have seen, the fierce crocodile watches over and feeds her young, and the python coils herself over her eggs, and will take no food till they are hatched. Moreover, we can scarcely look at the quaint shell-covered tortoise, or examine the heavily-mailed coat of the alligator, or the poison-fangs of the snake, without admiring the curious devices by which these animals have managed to survive in a world which once belonged to their ancestors, before our present swarm of warm-blooded animals multiplied and took possession of their kingdom.





## CHAPTER VI.

### THE FEATHERED CONQUERORS OF THE AIR.

#### PART I.—THEIR WANDERINGS OVER SEA AND MARSH, DESERT AND PLAIN.

IT is a warm sunny day in early spring, one of those few bright days which sometimes burst upon us in April, just after the swallows have come back to us, searching out their old nooks under the eaves, or their old corners in the chimneys, to build their

new nests. There they are, clinging with their sharp claws to the edge of the cottage thatch, while the impudent little sparrow, which has remained hopping about all the winter long, chirrups at them from a neighbouring apple-tree. Upon the grass-plot near a blackbird is pecking at a worm, and from the wood beyond a thrush trills out his clear and mellow song, accompanied from time to time by the distant cry of the cuckoo calling to his mate. For it is the love-time of the birds ; and as we watch them flying merrily hither and thither in the bright sunshine, we ask ourselves whether we must not have made a great leap on leaving the cold-blooded snakes and tortoises, since now we find ourselves among such merry, warm-hearted, passionate little beings, with their beautiful feathery plumage, their light rapid flight, their love for each other, their skill in nest-building, and their patient care for their little ones.

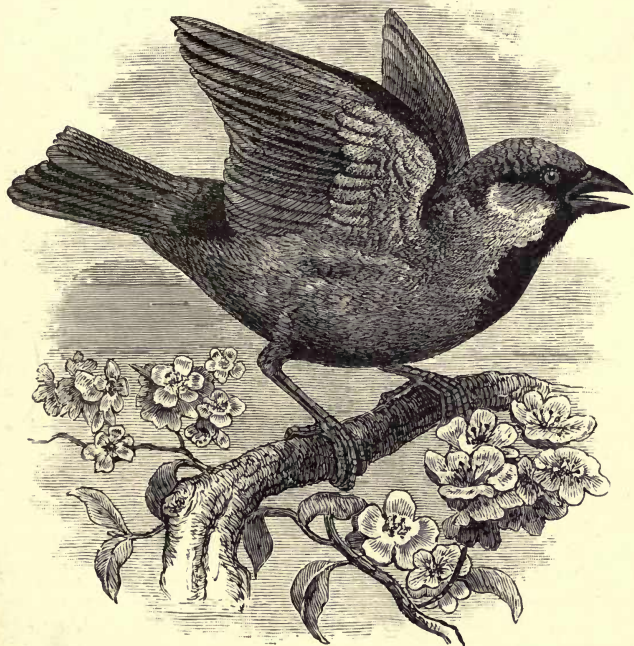
And, indeed, we have come into quite a new life, for now we are going to wander among the conquerors of the air, who have learned to rise far beyond our solid ground, and to soar, like the lark, into the clouds, or, like the eagle, to sail over the topmost crags of the mountains, there to build his solitary eyrie.

Even the little sparrow, which flits about by the roadside, can laugh at us with his impudent little chirp, as he flies up out of reach to the topmost branch of a tree. And yet a glance at his skeleton will show us that he has the same framework as a reptile, only it is altered to suit his mode of life.

True, his breastbone (*b*, Fig. 33) is deep and thin instead of flat, and those joints of his backbone which lie between his neck and tail are soldered firmly to-

gether, more like those of the tortoise, and he stands only upon two feet. Yet this last difference is merely apparent, for if you look at the bones of his wings

Fig. 32.



The Sparrow.

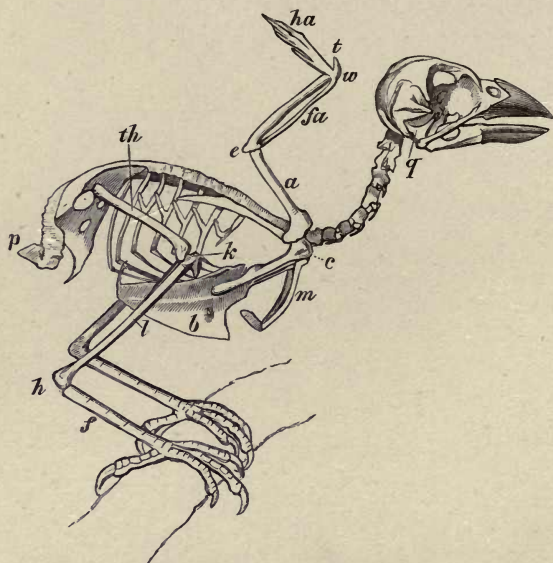
With wings raised, as in the skeleton on next page.

you will find that they are, bone for bone, the same as those in the front legs of a lizard, only they have

been drawn backwards and upwards so as to work in the air.

There is the upper arm (*a*) answering to the same part of the lizard's front limb (p. 103); there is the

Fig. 33.



Skeleton of a Sparrow (from a specimen).

*q*, Quadrate bone, peculiar to reptiles and birds and some *amphibia*; *b*, breastbone; *m*, merrythought or collar bone; *c*, coracoid bone, over which the tendon works to pull up the wing; *p*, ploughshare bone, on which the tail grows.

Wing bones—*a*, upper arm; *e*, elbow; *fa*, fore arm; *w*, wrist; *t*, thumb; *ha*, hand.

Leg bones—*th*, thigh bone; *k*, knee; *l*, lower part of leg; *h*, heel; *f*, foot.

elbow (*e*); then the two bones of the fore-arm (*fa*); then the wrist (*w*), and a long hand (*h*), which has



lost almost all trace of separate fingers, except the little thumb (*t*), which carries some feathers of its own, known as the "bastard" wing. Now when the sparrow is resting he draws back his elbow, folds his wrist joint, and brings the whole wing flat to his body. But when he wishes to fly he stretches his arms out and beats the air with them, and as his hand moves over most space, it is there that you will find the longest quill feathers, which stretch right to the tip of his wing; then next to these follow the feathers of his fore-arm, while those of the upper arm are short and close to his body, and over all these are the rows of covering feathers, which make the whole wing thick and compact.

Here, then, we have the lizard's front legs turned into a wonderful flying machine in the bird, and this in *quite a different way* from the flying lizards which lived long ago, and which had only a piece of membrane to flit with, like bats. And now what has happened to the hind legs, the only ones used as legs by the birds? Look at the sparrow as he clasps the bough with his toes, and you will, perhaps, be puzzled why the first joint of his leg turns back like an elbow and not forward like a knee. Ah! but that joint is his ankle, and the knob behind is his heel (*h*), for the bones of his foot have grown long and leg-like; and he always stands upon his toes, the rest of his foot forming a firm support to hold his body up in the air. Look at the skeleton and you will find his true knee (*k*) up above; and if you go to the Zoological Gardens and watch the Adjutant birds, you will often find them resting their whole foot upon the ground (see Fig. 34), and comical as

it looks, it will help to explain the curious foot and leg of a bird.

Already, then, we see that the bird is using the same bones as a reptile, though he uses them in a dif-

Fig. 34.



The Adjutant Bird.

Showing the foot resting from heel to toe upon the ground.

ferent way ; and besides these resemblances between the skeletons of birds and reptiles there are two special ones easy enough for us to understand. We saw in

the snakes and the lizards that they have a separate bone (9, Figs. 23 and 26) joining the lower jaw on to the head ; now you will find this same bone in the sparrow and in all birds (see Fig. 33), but in quadrupeds this bone is not to be found, the part representing it being changed into one of the bones of the ear. Again, the sparrow's skull is joined to his backbone by a single half-moon-shaped knob, which fits into a groove in the first joint or vertebra. This also we find in reptiles, while all higher animals have two such knobs, so that although they can nod the head upon these, they cannot turn it upon them, and consequently the first joint turns with the skull upon the second vertebra.

These, then, are some of the reasons why Professor Huxley tells us that though frogs and reptiles look in many ways so like each other, yet in truth the frogs must be grouped with the gill-breathing and fish-like animals ;\* while the cold-blooded reptiles, when we come to look closely into them, are linked with such different looking creatures as the bright and merry birds.† But we have also another and stronger reason for thinking that reptiles and birds are distant connections ; for in those far bygone times (see p. 92), when the huge land-lizards browsed upon the trees, the birds living among them were much more like them in many ways than they are now. From their skeletons and feathers which we find, we know that the strange land birds‡ which then perched on the trees had not a fan-shaped tail made of feathers, growing on one broad bone as our

\* *Ichthyopsida*—*ichthys*, fish ; *opsis*, appearance.

† *Sauropsida*—*sauros*, lizard ; *opsis*, appearance.

‡ *Archæopteryx*, see picture-heading, Chapter VII.

birds have now (*p*, Fig. 33), but they had a *long tail of many joints like lizards*, only that each joint carried a pair of feathers, and like lizards too they had *teeth in their jaws*, which no living bird has. They must have been poor flyers at best, these earliest known birds, for their wings were small and the fingers of their hand were separate more like lizard's toes, two of them at least having claws upon them, while their long hanging tail must have been very awkward compared to the fan-shaped tail they now wear. For some time they were the only birds we know of, but later on we come upon the bones of water-birds\* telling the same story. For some about the size of small gulls,† though they flew with strong wings and had fan-shaped tails, still had teeth in their horny jaws, set in sockets like those of the crocodile, while their backbones had joints like those of fishes rather than birds; and with them were other and wingless birds‡ rather larger than our swans, but more like swimming fish-eating ostriches, for their breastbones were flat, not thin and sharp like the sparrow's, and they had scarcely any wings, short tails, long slender necks, and jaws full of teeth, this time set in grooves like those of lizards and snakes.

In these and many other points the early birds came very near to the reptiles—not to the flying ones, but to those which walked on the land. And now, perhaps, you will ask, did reptiles then turn into birds? No, since they were both living at the same time, and those reptiles which flew did so like bats, and not in any way like the birds which were their

\* See picture-heading of this chapter.

† *Ichthyornis*, fish-bird.

‡ *Hesperornis*.



companions. To explain the facts we must go much farther back than this. If any one were to ask us whether the Australian colonists came from the white Americans or the Americans from the Australians, we should answer, "neither the one nor the other, and yet they are related, for both have sprung from the English race." In the same way, when we see how like the ancient birds and reptiles were to each other, so that it is very difficult to say which were bird-like reptiles and which were reptile-like birds, we can only conclude that they, too, once branched off from some older race which had that bone between the jaws, that single neck joint, and the other characters which birds and reptiles have in common.

But long ago they must have gone off each on their own road, the reptiles filling the world for a time, flying and walking and swimming, till they found at last that creeping was their most successful way of life; the birds on the other hand becoming more and more masters of the air and the water, so that, while keeping the same bones and parts as the reptiles, they have grown into quite different beings in their form and habits, giving up the long-jointed tail of the *Archæopteryx*, or ancient-winged bird, for the compact feathered fan which helps to balance them in their flight, and the teeth of the water-birds for the sharp and horny beak, which, together with their claws, is their chief weapon of attack and defence now that they have employed their front limbs as wings.

Nor shall we have far to look for the secret of their success in life. Just as the reptiles have an advantage over the naked frogs and newts by having strong scaly coverings in their skin, so the birds

have an advantage over the reptiles in that beautiful feathery plumage which covers their body, and the powerful muscles which work their limbs. For it is by means of these that they have been able to move quickly and travel far, and to develop that bright nervous intelligence which has grown more and more active as they have been carried into fresh scenes and experiences, overcoming new difficulties and enjoying new pleasures.

Remember for a moment how weak the lizard's limbs are, so that his body always drags upon the ground; and then look at the bird's tight grasp of the bough and the rod-like legs which raise his body above it. Watch him as he beats the air with his wings, rising and sinking, turning and swerving at will, and you will see that he has earned freedom, strength, and active life, by means of the strong muscles which move these legs and wings, and the feathers which provide him with an instrument for beating the air. Feel a sparrow's fat little breast, or see how much meat comes off the wing and breast of a pigeon, and then, if you consider that all this flesh is muscle used for moving his wings, you will not wonder at his easy flight. For the muscles of a bird's breast often weigh more than all his other muscles put together, and while one enormous mass of muscle in front of the breast works to pull down the wing, another smaller one, ending in a cord or *tendon*, passing like a pulley over the top of a bone (c, Fig. 33, p. 126), pulls it up, so that by using these, one after the other, the bird flies.

But where have the feathers come from,—those wonderful beautiful appendages, without which he

could not fly? They are growths of the bird's skin, of the same nature as the scales of reptiles, or those on the bird's own feet and legs; and on some low birds such as the penguins they are so stiff and scale-like that it is often difficult to say where the scales end and the feathers begin. All feathers, even the most delicate, are made of horny matter, though it splits up into so many shreds as it grows that they look like the finest hair, and Dr. Gadow has reckoned that there must be fifty-four million branches and threads upon one good-sized eagle's feather.

When these feathers first begin to grow they are like little grooved pimples upon the flesh, then soon these pimples sink in till a kind of cup is formed all round them, and into this cup the soft layer just under the outer skin sends out fibres, which afterwards form the pith. Round these fibres rings of horny matter form, and then within these rings, in the grooves of the soft pimple, the true feather is fashioned. First the tips of the feathery barbs, then the shaft, and then the quill appear, as the feather grows from below, fed by an artery running up into the pimple; till at last, when the whole is full-grown, the quill is drawn in at the base, and rests in its socket, complete.

Some of these feathers are weak and soft, with slender shafts and loose threads growing all round them, and these are the downy feathers which lie close to the body and keep the bird warm. Others, which cover the outside and form the wings and tail are flat, with strong quills and shafts, and a double set of barbs growing upon each shaft; and if you look at these wing feathers under a strong microscope you will see that they have a special arrangement

for helping them to resist the air. For not only have all the little featherlets or *barbs* rows of other featherlets or *barbules* growing upon them, but these again are covered with fine horny threads, often hooked at the tip, which cling to the next barb, so that the feather is woven together as it were, in a close web, and if you strike it against the air you will find that it resists it strongly.

Now in a bird's wing the feathers are so arranged that they lap one under the other from the outside of the wing to the body, so that when the bird strikes downwards they are firmly pressed together, and the whole wing, which is hollow like the bowl of a spoon, encloses a wingful of air, and as this is forced out behind, where the tips of the feathers are yielding and elastic, he is driven upwards and forwards. When, however, he lifts his wing again, the feathers turn edgeways and are separated, so that the air passes through them, and he still rises while preparing for the next stroke. All this goes on so rapidly that even the heron makes 300 strokes in a minute, and the wild duck 500, while in most birds they are so rapid that it is impossible to count them; yet all the while the little creature can direct his flight where he will, can pause and direct his wings to the breeze so as to soar, can swoop or hover, wheel or strike, guiding himself by the outspread tail and a thousand delicate turns of the wing.

All this complicated machinery, however, would not have served the bird much if his body had been as heavy, and his blood as cold, as those of the lizard and the crocodile. But here he has made a great step forward. In the first place, he has a heart with



four chambers, two on the right side and two on the left; and while one of those on the right side receives the worn-out blood from the body and pumps it *to* the lungs to be refreshed, one of those on the left side receives it *from* the lungs when it is refreshed, and the other pumps it into the arteries to feed the body. So here we see for the first time among our backboned animals a creature whose good and bad blood are never mixed in the heart (compare pp. 23 and 76), but it gets all the benefit possible from its breathing, and the blood is kept fresh and pure.

Moreover, a bird's lungs are large, and are continued into several large air-sacs, which in their turn open out into tubes which carry air actually *into the bones*, many of which are hollow instead of containing marrow like those of other animals.\*

And now we begin to see how wonderfully these little creatures are fitted for flying. With all this air within them, not only is their blood kept hot by constant purifying, but their bodies are much lighter than if their bones were solid, and they can present a much broader surface to float upon the air without increasing equally in weight. Meanwhile, their feathery covering prevents the cold air around from chilling them, so that they are not only warm-blooded animals, but actually warmer-blooded even than ourselves.

Thus, then, Life has spread her feathered favourites over the world. For them there are no limits except the extreme depths of the water below, and the

\* Some chamæleons and geckos also have air-tubes passing from the lungs into the body, and the crocodile's skull is full of air-cells; but the two phenomena are not connected as in birds, and other parts of the skeleton or of the skin-covering, being heavy, have a counteracting effect.

height beyond the atmosphere above. Wherever air-breathing creatures can go, there some bird may be found. On the dizzy ledges of inaccessible cliffs, on the wide bosom of the open ocean, on the sandy wastes of the desert, in the tops of the highest trees, on the cloud-capped peaks of the mountains, diving or swimming, flying or soaring, running, perching, darting, or sailing for miles and miles without one moment's rest, they find their way everywhere, and there is no spot from the icebound countries of the Arctic zone to the warm bright forests of the tropics where they do not penetrate ; while their sharp eyes, kept free from dust and harm by a third eyelid moving rapidly sideways,\* see far into the distance, and thus as they soar into the sky they have a power, possessed by no other animals, of overlooking a wide domain. Nor have they been obliged, like the reptiles, to take up strangely different forms to suit their various habits, for so wonderfully does their body meet all their wants that very slight changes, such as a broad body and webbed feet for the swimmers, long bare legs for the waders, a long hind toe for grasping in the perchers, and sharp claws and beak for the birds of prey, fit each one for his work, and are some of the chief distinctions we can find between them.

Even the heavy running birds, the Ostriches of Africa, the Rheas of South America, and the Emus and Cassowaries of Australia, still remain truly bird-like, though their wings are unfit for flight. True, their breastbones are flat instead of keel-shaped, for they have no need of strong muscles to move their wings,

\* This third eyelid is a fold on the inner side of the eye ; some reptiles and amphibians have it, and so have the marsupials and many of the higher animals.

which now serve only as sails to catch the wind as they run, and in many other ways they are an older type than our flying birds ; but their wing bones are formed as if they were used for flying, and their

Fig. 35.



The Ostrich \* at full speed.

feathers, though loose and downy because they have no little hooklets, are like those of other birds.

Strong powerful creatures they are, even in confinement. Yet how little can we picture to ourselves, when we see the Ostrich trotting round his paddock in the Zoological Gardens, with his wings outspread, what he is when he courses over the free desert !—

“ Where the zebra wantonly tosses his mane,  
With wild hoof scorning the desolate plain ;  
And the fleet-footed ostrich over the waste  
Speeds like a horseman who travels in haste.”

---

\* *Struthio camelus*.

There the soft pads under the *two toes* of each foot rebound from the yielding sand as his well-bent legs straighten with a jerk one after the other, making his body bound forward at full speed. Then he raises his wings, sometimes on one side, sometimes on both, to balance himself, and to serve as sails to help him ; and with this help his stride is sometimes as great as twenty feet, and he dashes along at the rate of twenty-six miles an hour. He is not so heavy as he looks, for many of his bones are hollow, his feathers are downy and soft, and his wing-bones are small ; and it is to his featherless thighs that you must look for the strong muscles to which he trusts for all his speed, as with outstretched neck he bounds across the plain.

If we go back to long bygone times, before the lion, the leopard, and other ferocious animals found their way into Africa, we can imagine how this great running bird took possession of the land and became too heavy for flight ; while as time rolled on, he gained that strength of body and leg which now is his great protection as he dashes along, his four or five wives following in his train. The ostriches can travel over wide distances from one oasis to another, feeding on seeds and fruit, beetles, locusts, and small animals, and fighting fiercely with legs and beak if attacked. And when the springtime comes the wives lay their eggs in a hole scooped in the sand, or often in some dry patch of ground surrounded by high grass, till sixteen or twenty are ready ; and then they take their turn (the father among the rest) of sitting upon them, at least at night, even if they leave them to the heat of the sun by day. And



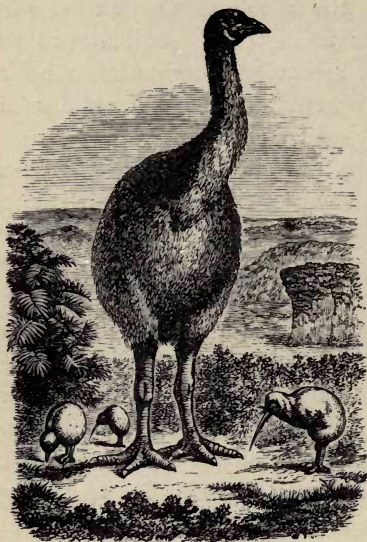
when six weeks have passed the father grows impatient, and, pressing the large bare pad in front of his chest against each egg in turn, breaks it, pulls out the membranous bag with the young bird in it, shakes him out, and, swallowing the bag, goes on to another. In this way the whole downy brood are soon set free, and begin picking up small stones to prepare their gizzard or muscular second stomach for grinding, while their parents scrape the sand and find and break up food for them.

So the ostrich lives its life in Africa, from Algeria right down to Cape Colony; while its smaller and lighter-coloured relations, the Rheas, with their *three-toed* feet, course over the plains of Paraguay and Brazil, on the other side of the Atlantic, often swimming from island to island, in the bays or across the rivers, but quite unable to fly with their soft hair-like feathers, though their wings are larger than those of the ostrich. Then when we turn to the East we find other running birds; the Cassowary, with its three toes, its horny helmet, its five long single feathers, and its five naked pointed quills in the place of a wing, feeding on fruit and vegetables in New Guinea, or sharing the dreary scrubs of Australia with the almost wingless Emus wandering in pairs, the only constant married couples among the running birds.

Nor is New Zealand left without a representative of this family, for there we have the curious little Apteryx or Kiwi (Fig. 36), with its thick stumpy legs, its long beak, and its soft downy body, under which are hidden its aborted wings. Perhaps it is because he is small and insignificant that the apteryx has lived on

till now, crouching under the bushes by day and creeping about in the twilight, thrusting his long nose-tipped beak into the damp ground to draw out the worms. For long ago, though in the memory of man, as

Fig. 36.



Wingless birds of New Zealand.

The giant Moa (*Palapteryx*) and the tiny Apteryx. The Moa is no longer to be found alive.

of Madagascar, the *Æpyornis*, whose gigantic bones and eggs, three times the size of ostrich eggs, have been found, though the bird itself has never been seen.

But these are gone now, and their relations the Emus are fast following them ; for however well these

we learn from the traditions of the Maories, other wingless birds called Moas,\* which were six or seven feet high, lived in New Zealand, and had fierce fights with the natives. We find their bones now, often charred from having been cooked in the native ovens, and when they are put together they give us skeletons which show that these birds must have been as formidable as that great bird

\* *Dinornidæ*, of which *Dinornis*, a still more ancient form, must have been ten feet high.

flightless birds may flourish on the broad plains and deserts, where only their wild companions are around them, they are sadly at the mercy of man. The proud eagle can fly far beyond the reach of the hunter's gun ; the little lark, if she be only wary enough, may trill out her song in the blue vault above and leave the cruel destroyer far below ; but the emu and the cassowary, the rhea and the ostrich, have lost the power to leave the earth ; and if it were not that we prize the two last for their feathers, they, too, like their companions, might live to rue the day when they became runners instead of conquerors of the air.

It is very different, however, with the water-birds, for they have not only kept the power of flight, but have gained the double advantage of also floating safely on the water. Look at our common wild duck. We might have taken him just as well as the sparrow for our type of a bird, and yet while the sparrow leads a land life in the trees, the duck's home is on the water, and many of his relations live cradled on the open ocean.

See his broad boat-like body which floats without any effort of his ; notice how closely it is covered with short thickly-grown feathers, which protect him from the chilly water, while he keeps them well-oiled with his beak, from an oil-gland which all flying birds have at the base of the tail. Watch how he swims, drawing his webbed foot together as he brings it forward, and spreading it like a fan to strike the water as he drives it back. Then, as he feeds, watch him gobbling in the mud and then

shaking his head as he throws his beak up in the air. For he, like all ducks and geese, has a set of thin horny plates inside his broad bill, and they sift the mud, while the tender tooth-like edges of his beak and tongue feel out the suitable morsels.

All this time he is a water animal, but when he rises and flies he is also master of the air, for his strong wings carry him stoutly, so that he can migrate from one pool to another ; or in winter, when the pools are frozen, to the open sea. He is by no means the best flyer of his family, and yet he is spread over Europe and North America, and even as far east as Japan, while his ocean-loving cousin, the eider-duck, lines her nest and lays her eggs high up in Arctic latitudes, and dives and swims in the open ocean. So too his relations, the wild swans and geese which wander in the lakes and swamps of Lapland, Siberia, and Hudson's Bay, feeding on water-weeds, worms, and slugs, build their nests in the summer in the far north, and then fly thousands of miles southwards to their winter homes, their strong wings whirring in the air as they go.

Yet these are scarcely as true sea-birds as the divers, the Guillemots and Puffins, the Auks and Grebes, which swim out all round our coasts, and dive deep down to feed on the fish below. How clumsy they are on land and how skilful in the water ! You may see numbers of guillemots and puffins in summer on the high cliffs of the north of Scotland, or of Puffin Island in the Menai Straits ; the guillemots laying their eggs on the bare ledges, and the puffins in holes which they burrow in the cliff's face ; and they sit so doggedly upon their



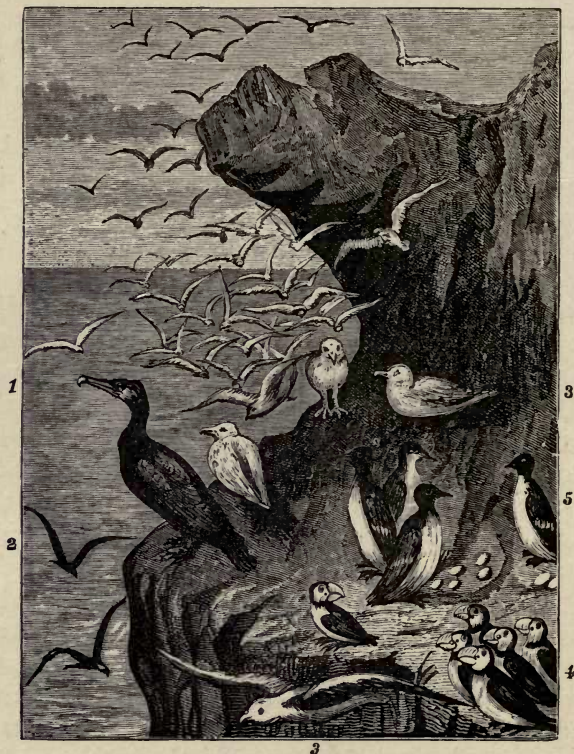
nests, and shuffle and hop along so awkwardly, that men climbing up, or let down by ropes from above, knock them over as they go. But wait till the eggs are hatched, and the little ones have broken out of their shelly prison, each one cracking his shell from inside by means of a little horny knob, which all baby birds have for this purpose at the end of their beak, and which falls off when they are fairly born. Then fathers, mothers, and young ones, able to take care of themselves as soon as hatched, launch out into the open sea in August, and there is a sight of diving and swimming and fishing grand to behold. The awkward legs, placed so far back on their body, now serve as powerful oars and rudders to drive their smooth satiny bodies through the water. Their thin narrow legs cut through the waves like knives, while their short stumpy wings, closely laid against their down-covered bodies, keep them from being chilled, and so do the air-bubbles which are entangled in their short thick feathers, and which give their backs the appearance of being covered with quicksilver when they dive\* after the fish below.

And then when the winter comes, those which have bred in the north fly and swim southwards to our coasts, where they are joined by the true divers and grebes which have come from the rivers and estuaries, where they have made their nests on some reedy bank or floating upon the water, and lived till their young ones are strong. This is their sea-faring time; and whether near the shore, or miles out at sea, they dive and swim and make the ocean their home till spring comes round again.

\* This beautiful effect may be seen from below when the guillemots are fed in any of the public aquariums.

Still all their roving is done chiefly by swimming, and they leave it to the Gulls and Petrels, the Terns

Fig. 37.



A Group of Sea-Birds.

1. Cormorant. 2. Black-winged Tern. 3. Gulls. 4. Puffins.  
5. Guillemots.

and the powerful Cormorants and Gannets, to fly hither and thither over the wide sea. These birds

have indeed reached the climax of a seafaring life, with their powerful wings, their sharp and often hooked beaks, and their short legs. They, too, feed upon the water, coming up with a fish in their mouth, but they do not dive under and swim like the guillemots. On the contrary, flying is their forte; they swoop down, and scarcely have they gone a few feet under water than they are up again, skimming on the waves as they swallow their prey, which may be anything from dead floating creatures to living fish which have ventured too near the surface. Yet they swim well too, and though the common gulls rarely go more than twenty miles from the shore, they are quite at home on the open ocean, and there is no habitable part of the globe without them. Still more venturesome are the petrels:—

“ Up and down, up and down,  
From the base of the wave to the billow's crown,  
And amidst the flashing and feathery foam  
The stormy petrel finds a home.”

They are smaller and lighter than the common gulls, and are never so happy as when darting over the foam of an angry sea, while their more delicate relations, the Terns or sea-swallows, with their long pointed wings and forked tails, are taking shelter in the quiet bays.

Lastly, king among all sea-flying birds is the gigantic petrel, the Albatross. What a grand fellow he is when he is once on the wing, though he has some difficulty in starting. Flying onward, onward, without resting day or night, his pure white body near down to the water, his large head and short thick neck slightly bent, and his long,

narrow, black wings, often measuring ten feet from tip to tip, widely outspread, he beats a few powerful strokes, and then sails along, using his head and tail as rudders to turn his wings to the wind. Often he will follow a ship for days, sailing round and round in circles, and yet keeping easily ahead, while all the time his bright eye watches the water to catch every chance of food. Jelly-fish, cuttle-fish, and real fish of all kinds, together with any dead creatures he may find afloat,—all is food to him, and his powerful beak will cut through the toughest morsel. For days and days he will fly on, never tiring, and feeding as he goes ; and if he alights for a time upon the water he rises with difficulty, unless the waves are high and bear him up on their crests ; and when he comes to rest it is on some island in mid-ocean, where he seeks a mate, and brings up his nestlings either on the low ground or on the top of a high mountain, in a hollow lined with grass and moss. Truly, if we look at the far-flying albatross we must acknowledge that the wings of a bird have given him the command of the sea as well as the land.

He forms a strange contrast to the curious stunted bird form which we may find in those same islands where the mother albatross lays her eggs. For there, in the islands of the South Pacific, close by the side of the albatross nest, are whole groups of strange-looking birds, the Penguins, with their fat, white, feathered breasts, their dark head and beak, their curious hind legs set right at the end of their body, and their small paddle-like wings, covered with short stiff feathers, quite useless for flight. We have come upon a strange story here, for our penguin is



a low relation of the guillemots and puffins whom we left in the north, and, like the great northern auk, which has now been extinct for many years, he has lost the use of his wings. He has no dangerous enemies on these rocky inaccessible islands, where he and his companions form dense penguin rookeries

Fig. 38.



Albatrosses and Penguins.

upon the ground, unless it be the large gulls or skuas which steal the eggs. Nor has he any need for flying, for the sea is all around him, and even if he wishes to migrate to warmer waters in winter, he does so by swimming. Therefore we find that his wings are lost to him for any flying purpose, and

nothing can be more awkward than he looks, shuffling or hopping along with outstretched arms, like a fat baby, till he comes to the water's edge. But when he dives in and swims it is quite a different matter. Then his easy wavy motion, like that of a seal, shows at once that his stumpy imperfect wings are excellent fins, while his feet serve him both as oars and rudders.

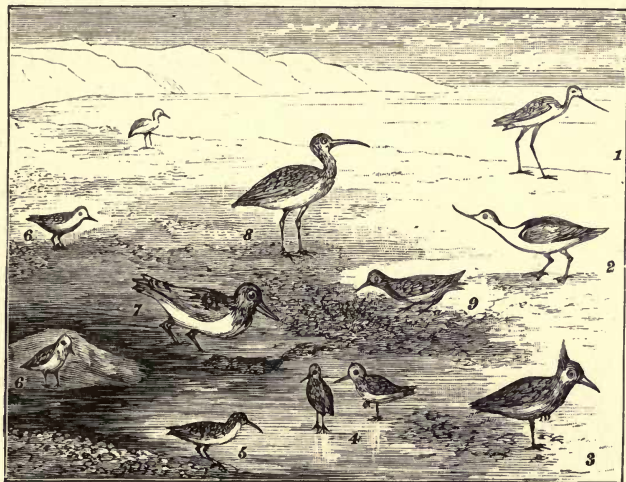
Thus we have traced our swimming and web-footed birds to their extreme types—the strongest flyer in the albatross, and the lowest, most fish-like bird in the penguin ; while, if we were to follow the pointed-winged frigate-bird in his flight, or see the pouched pelican in his home, we should find another group of these web-footed birds, no longer merely standing upon rocks, but perching upon the boughs of trees, and building their nests by the side of rivers in warm countries nearly all over the world, or among the mangrove bushes of the tropical islands.

And now, if we return to our northern shores and pause upon the broad wet sands at low tide, we may chance to find whole flocks of active little birds hovering and running and wading in the water, or pecking on the sands ; and the double-noted whistle of the Curlew, or the musical cry of the Peewit (or Lapwing), tell us at once that they are “waders,”—birds with bare legs, flat toes, and long beaks, which drop down on the muddy flats by the sea, seeking their food at the edge of the water. There they are, Curlews and Dunlins and Sandpipers, Plovers and Knots, Oystercatchers feeding on mussels and limpets, and Turnstones tilting up the lumps of mud

to find food beneath. One and all they are running hither and thither, to seize here a shrimp or sandhopper or a tiny fish, there a worm or a sea-slug ; making the most of their time before the sea comes up and covers their feeding ground.

Here we have no webbed feet or legs set far back, but three long, flat, straight toes, well fitted

Fig. 39.



A group of Wading Birds.

1, Stilt ; 2, Avocet ; 3, Peewit ; 4, Dunlins ; 5, Curlew Sandpiper ;  
6, Sanderling ; 7, Oystercatcher ; 8, Curlew ; 9, Turnstone.

for walking on marshy ground and treading lightly on water-plants, and slender bodies well balanced on long thin legs, which move so quickly as they run that you can scarcely see them ; while, when they fly, their long wings carry them lightly through the air, with their legs stretched out behind.



What connection can there be between these active light little beings, and the broad-bodied web-footed swimmers? Go to the Zoological Gardens, and look at the Flamingo, with his long legs and

Fig. 40.



The Flamingo.

A duck-billed and web-footed bird  
among the waders.

curious curved beak.

He is of the true swimming type, with his webbed feet and his sieve-like bill, with its rows of horny strainers like the geese; yet he feeds by wading in salt-water lakes and pools on the sea-shore, raking the bottom for food, and showing how a swimmer and a wader may once have had the same starting-point, before the one went out to sea, and the other in to shore. And then when we come back to our own little waders, and learn that they visit the sea, and feed upon the wet

sands from the autumn to the spring, and then fly inland to build their nests in the damp meadows,



feeding on earthworms, slugs, and insects of the land, we can see what an advantage this double life must be to them.

Notice, too, how shy and timid they have become from living among other animals, and watching for every danger. Try to get near one, and see how it will run on, turning its head hither and thither to watch, and at last will rise and be out of sight in no time. Or go and look for plover's eggs on the swampy grounds in our northern counties in the early summer, when

“ . . . . . from the shore  
The plovers scatter o'er the heath,  
And sing their wild notes to the listening waste.”

The mother will no sooner see you than she will crouch down, running along a rut, and then move slowly away with a drooping wing as if wounded, hoping to make you follow her and pass by the little earthy hollow where her precious eggs are lying. The experience of life has made these little ground-nesting birds very intelligent, since they have had a land as well as a watery home, and the little moor-hen, which, like the rails and crakes, has taken entirely to a freshwater life in ponds, brooks, canals, and rivers, has learned to hide her nest so skilfully, and to dive and swim so cleverly, that even a trained water-spaniel often loses her when close upon her home.

And as the swimmers have their large birds in the albatross, so the waders too have theirs in the Herons, the Storks, and the Cranes. Who does not know how the storks fly in flocks to the sunny south in winter, and come back in the spring to build their

nests in the chimneys of the houses of Holland and Germany, feeding on the banks of rivers, and in the fens on lizards, fish, frogs, and water-snakes ; or how the cranes pass their summer in the stormy north, and their winter among the old ruins of Egyptian greatness? But the herons remain with us all the year, feeding on shrimps and crabs on the weed-covered shores, or more often in ponds and lakes upon frogs, water-rats, and fish. How patiently you may see a heron stand with his head slightly bent, still and motionless, till a fish passes by ! Then quick as a flash of lightning, his head darts forward, impaling or seizing the prey in the strong beak, and he is off to eat it at his leisure. Thus he lives a solitary life all the year until the spring-time, when he flies off to some group of lofty trees where for generations his family have built their nests, and, meeting with his fellows, piles up huge masses of sticks and grass among the tangled boughs.

And there the young herons are hatched and fed in the ancient heronry till they can perch and fly. For now among the waders we have come to birds that can perch, as we did among the swimmers (see p. 148). The heron has no longer the three-toed flat foot of the wader, with perhaps a slight spur behind, but a large fourth toe, with which he can grasp the bough ; and as he flies across the country, uttering his strange harsh cry, often rising even higher than the hawks and falcons, and alighting on the top of some tall tree, few people would think of classing him among the waders, so like is he to those true land-birds whose life is spent in the air and whose home is in the trees.



## CHAPTER VII.

### THE FEATHERED CONQUERORS OF THE AIR.

PART II.—FROM RUNNING TO FLYING: FROM MOUND LAYING  
TO NEST BUILDING: FROM CRY TO SONG.

So the deserts and plains have their ostriches and cassowaries, the open ocean its albatrosses and its penguins, the shores their ducks, gulls, and waders, and the little inland pools and marshes their water-

birds, which come there to build their nests and seek for food. Yet these are after all not by any means the larger portion of the bird world. It is in the woods and forests, the moors and pastures, on the solitary mountain peaks above, and in the snug valleys nestling below, that we find the myriads of song birds and game birds and birds of prey ; of climbing birds such as the Woodpeckers ; swiftly sailing birds such as the Swifts, cooing Wood-pigeons and cawing Rooks ; terrible Eagles and Hawks, or sweet-singing Nightingales and Thrushes.

All these birds have had a very different education from that of the far-sailing albatross or the running ostrich. They have grown up in the midst of innumerable dangers ; for enemies of all kinds—beasts and reptiles and other birds—live all round about them, making food scarce and destroying their young, so that of the millions born into the world thousands upon thousands perish every year before they grow up. We should expect, then, that these land birds would learn many devices for protecting themselves and their little ones. The guillemot can afford to lay her egg on the bare rock, for few animals can climb the high cliffs where she makes her home ; and the penguin on her solitary island may lay hers in the mud on the ground. But the little lark must look carefully for high grass in which to build her nest, and the rook must weave a strong basket-work of twigs to make a home for her nestlings in the top of the high elm.

Moreover, the land birds cannot sleep safely on the ground, where weasels and stoats, foxes and wild cats, prowl by night in search of prey ; they must



take their rest on the boughs of the tall trees and cling on by their toes even when they are in the deepest slumber. This they could not do if they had the stumpy cushioned feet of the ostrich, the webbed feet of the duck, or the flat three-toed feet of the waders. It is the fourth toe turned backwards, and growing very long in many of the perching birds, which gives them their grasp; while a special muscle, beginning behind the thigh (*th*, Fig. 33, p. 126), coming round over the front of the knee (*k*), and then passing behind the heel (*h*), and on to the toes, keeps them bent. Picture for a moment this muscle sending its cords or tendons from behind the leg over the knee, and then drawn back by the heel, and you will see that the more heavily the bird sleeps, pressing upon its legs, the more the knees will be bent forward, the tighter the cord must be stretched, and the stronger the grasp will be upon the bough.

Again, as to food, the land birds will be more closely pressed than those which can at all times fish in the sea. There is great scarcity of land food in the winter, while in summer whole flocks of newly-born fledgelings are clamouring for their daily bread. So we shall find that every kind of eatable thing is turned to account, and we have among land birds seed-eaters, vegetable-feeders, and fruit-eaters; insect-devourers, and feeders on slugs and worms and snails; and flesh-eaters which feed on other birds, or on mice, bats, and larger animals; while large flocks of birds of all kinds visit different parts of the earth in the various seasons, going north in summer to build their nests, and south in winter, in search of food. All these birds live chiefly in the air; while on the

ground there are the scratchers—fowls, partridges, turkeys, and grouse, which rake out the hidden grains, and rarely rise into the air except when they are frightened, or to roost on the trees at night. And between these ground birds and the true tree birds we have the doves and pigeons, some of which feed on fallen seed and grains, and others on fruit. And each and all of these birds have some difference in beak and claw, in their manner of nest building and rearing their young, and in their habits and ways, which enables them to make the most of their lives.

Even nest building does not come to all land birds by nature, and, as we shall see, it depends very largely on the habits and the structure of the builders. Thus the Partridges, and their relations the Pheasants and Grouse, lay their eggs in the thick grass of the meadows or among the heather, and at most sometimes scratch together a few dry grass blades for a bed. In this they remind us much of the ostrich family, which also scrape a hole in the ground for their eggs and scratch food for their children; and in fact there is a group of curious heavily-flying birds, called Tinamous, in South America, which are so like quails and partridges on the one hand, and ostriches on the other, that they lead us to wonder whether it was not from the ancestors of such birds as these in ancient times that the heavy running birds started on one road, while the lighter and swifter birds took to the wing.

The wings of all the scratching birds are even now short and round, and their flight is feeble. Their chief home is on the ground, where they crouch

among the thick herbage when the keen-eyed hawk is hovering overhead, never taking to their wings till no other chance is left them. The mother partridge runs many dangers as she sits upon her dark-coloured eggs in some sheltered spot, for weasels and stoats will attack her and steal her eggs if she leaves them for a moment, or kill her herself if they can take her unawares in the dark night. She could never hope to rear her young ones if they did not come out of the egg well covered with down, and able to run and pick by her side while she and the father scratch the ground with their short blunt claws to get ant-cocoons, and later on worms and insects for them.

Yet so well does scratching answer, in getting at buried food such as other birds cannot find, that there are a large number of these ground birds all over the world. The Guinea fowls of Africa, the spurred Peacocks, Pheasants, and Jungle fowls of India (from which last our tame fowls probably come), the wild Turkeys of America, the Quails which live in all parts of the old world from Australia to England, and the Ptarmigans of our northern countries, which put on their white plumage in winter—all these show how advantage has been taken of every nook in which ground birds could find shelter. We find them hiding in thick jungles and shady woods, or even in open ground among high grass and corn, scratching mother earth for their daily food; washing not in water but actually in the dust, by rolling in it, and then shaking it off; escaping many dangers by wearing a plumage very much the same in colour as the different grasses and

leaves among which they hide; and feeding on insects, worms, and seeds, and whatever they can find upon the ground or under it.

And when we travel far off to Australia, we find ground birds which do not even sit on their eggs, nor take care of their young, but leave them

Fig. 41.



Brush turkeys \* and their egg mounds.

as reptiles do to be hatched in the sun. The Brush-turkeys and Megapodes of Australia and the islands near, and the Maleos of Celebes—all of them scratching birds—come out of the thick jungle and lay their brick-red or pale-coloured eggs on the shore, never

\* Talegallus.



taking any more notice of them. The maleos simply scratch a hole in the sand and bury the eggs, the brush turkeys and megapodes \* scratch together all kinds of rubbish and dead leaves, carrying them in their long curved claws, and adding them to the heap till they have made a mound sometimes more than seven or eight feet high, and twenty feet across at the base ; an astounding size, when we consider that the brush turkeys are not nearly as large as a good-sized turkey, and the megapodes not larger than hens. It is to these mounds that the mothers come about every ten days, and lay an egg *up-right*, till each has laid eight or nine, and then she comes no more ; but after many weeks the little chicks work their way out fully fledged, and fly away to get their own living. The probable reason, Mr. Wallace tells us, for this curious habit of mound-building, is that the eggs are so large that the mother can only lay one every ten days, so that if she sat upon them she would be worn out with fatigue and want of proper food before they were all laid and hatched.

We see then that the scratching birds live nearly all over the world, yet, no doubt, it is a disadvantage to them that in their ground life they have become so heavy that they cannot fly so lightly or so far as their near allies, the pigeons, which, like them, feed on the ground. For the Pigeons have already made many steps forward in life. Their wings are strong, so that they can fly for great distances ; their toes are slender and well fitted for

\* Megapodidæ or large-footed birds.

perching; and though it is true that our tame pigeons and the wild rock-pigeons from which they are descended do not build nests, but lay their eggs in dovecots or church towers, or, if they are wild, in holes in the rocks, yet the beautiful blue-gray wood-

Fig. 42.



Wood-pigeon on her nest.

pigeon, with her pure white collar and soft cooing note, builds a nest in the trees—

“ The stock-dove builds her nest  
Where the wild flowers' odours float ; ”

though it is but a rough one, made, as well as her weak feet and bill can do it, of a few stout twigs, laid so loosely that her two little white eggs may be seen from below, and even sometimes fall through.

Yet, though but a beginner in nest building, she is a true tree bird, and her little ones are born naked and helpless, far out of reach of the ground, and

must be fed and cared for till they can fly. So she feeds them with infant pap from her own mouth. The "crop" or bag in which the partridge or hen stores the grain she picks up is large and single; but the pigeon has two bags, one on each side of the throat, and when she is feeding her young these bags secrete a large quantity of milky fluid, which, mixing with the tender shoots she has pecked off in the spring, or with the oily seeds she has gathered for her autumn brood, makes a soft food, which she pours into the mouths of her nestlings till they fly and feed themselves.

In the pigeons, then, we are gradually rising from the ground birds,—where the father generally has many wives\* and the young ones run as soon as they are hatched,—to the tree birds, where father and mother, taught by the helplessness of their brood, share the cares of nest building and the pleasures of love. Even the pigeons did not all at once become tree birds, for we have them in all stages now from the ground to the air. Many years ago, in the island of Mauritius, there were heavy flat-breasted pigeons, the Dodos, which lived entirely on the ground without the power to rise, so that when the Dutch settled there, bringing rats with them in their ships, the Dodos soon fell victims to the intruders, and now there is not one left. Again, in New Guinea now, there are ground pigeons which fly heavily and slowly, and only go to the trees to roost. Then come our own tame pigeons, the rock-pigeons, and the stock-dove which builds in holes in the trees; and then our wood-dove and his

\* Partridges, quails, and some others are exceptions, and pair.

relations, with their rude nests and their mixed food of grain and grass. And among these are the wonderful long-winged passenger pigeons \* of America, which fly in flocks of hundreds of thousands through Ohio, Kentucky, and Indiana, in search of nuts and seeds, breaking down the boughs of the trees by their weight where they alight, and then darkening the whole sky as they start off again in a succession of vast multitudes to another forest where beech nuts, acorns, and chestnuts are plentiful, or to the rice-grounds of Carolina, to take their fill.

And, lastly, we come to the beautiful green fruit-eating pigeons of India and the East—the feeders on nutmegs and palm-fruits and juicy berries of all kinds. These are true tree birds, difficult even to find, so like are they to the colour of the leaves ; yet they still build the loose untidy nests of their kind.

Nor need we wonder at this, for fine nest building requires both strength and delicacy in the bill and feet ; and the next group of birds escapes it altogether by finding or making holes in trees and banks, and lining them with moss or leaves. This group is the Climbers, which come, as it were, between the ground birds and birds of active flight, for they clamber swiftly up the trunks and over the branches of trees in search of fruits and insects, seldom going down to the ground, but flitting from tree to tree to find fresh hunting grounds.

What is that green object, about as large as a small squirrel, which we see mounting the trunk of one of the elm trees, as we lie resting on the moss

\* *Columba migratoria*.



in some quiet wood? There it goes, dodging now to this side, now to that, with its head well lifted and its stiff tail bent against the trunk. It is the green woodpecker at his work. His long large feet, with toes divided *in pairs*, two in front and two behind, take firm hold of the tree with their sharp

Fig. 43.



The great green Woodpecker.\*

claws ; his breast, which is flatter than that of most birds, lies close against the bark, as he mounts by a number of rapid jumps, which are made by pressing his strangely stiff horny tail against the trunk, while he hops forward with both feet, making a slight

\* *Gecinus viridis*.

rustling noise, and moving so fast that it is difficult to see how he does it.

Now he pauses ; it is to try a suspicious place in the bark, and tapping it with his beak he finds that it gives a hollow sound. This tells him at once that it is rotten, and there is an insect within ; and pecking a hole with rapid blows of his chisel-like bill, he inserts his narrow bill, and darts a long gluey tongue, with barbed tip, into the dark passage, bringing out the intruder, which is swallowed in a moment. A strange tongue this is of the woodpecker, for it has two long bony branches at its roots, and each one is like a bow bent under and round the back of the bird's head, and as these bows are tightened or slackened by the slender muscles the tongue is drawn in, or thrust out to an extraordinary length. Moreover, it has at its tip a horny covering beset with tiny barbs, and every time it goes back to the mouth these are bathed in gluey slime to catch the next insect it may meet. Nor is the woodpecker obliged always to drill for his food. The tiny ants, as they wander up and down the trees, the beetles and bees settling on the branches—all may fear this gluey weapon, for all alike disappear within the long thin beak.

And now, perhaps, our friend has flown to another tree, and is some way up it. Where is he gone ? Climb up and look, and you will find a small round hole, small outside but not inside, for the woodpecker has hollowed out the soft rotten wood, and within, if it be early summer, the mother is still sitting upon five or seven pure white eggs, out of which the naked little ones will soon creep. He is a clever fellow the

woodpecker, but he is by no means the chief or most conspicuous of the climbers, for in this group we have some of the most gaudy and remarkable of birds. The brilliantly-coloured Barbets, the gaudy-headed Toucans, with their clumsy bills and long barbed tongues, and the gorgeously-tinted Parrots and Parroquets, with their soft fleshy tongues so well adapted for speech, are all climbers, with toes divided two and two, and they wander about the trees of South America and the East, feeding on fruits and seeds.

Where in any other part of the animal kingdom can we find so many brilliant colours crowded together as in the plumage of birds, and especially in birds of tropical countries? The large land animals cannot afford to wear such bright coats lest they should attract their enemies, nor can even birds often put on gay plumage in our northern climates, where the trees are bare for half the year. But in warm sunny latitudes, where the trees are always green and the foliage thick and heavy, and where brilliant fruits and flowers often peep out among the leaves, the gaily-coloured birds can wander in comparative safety, and even the gaudy parrots are not easily detected as they clamber from bough to bough, using not their *tail* like the woodpecker, but their *beak*, as a third foot to hold on by as they climb.

None of these birds build nests; indeed, they could hardly do so with their clumsy beaks and thick heavy feet; they either, like the ground parrots, put together a few leaves in hollows of the earth or in ants' nests; or, like the fruit-eating parrots and toucans, they lay their eggs in tree-holes, where the

bright-coloured mother is safely hidden till she is set at liberty again. Even the cuckoos which, though they are climbers, have taken much more to the wing than their associates, sometimes avoid the trouble of nest building by laying their eggs in the nests of other birds, as our own spring visitor always does.

Fig. 44.



The Kingfisher.\*

Some of them, however, in America and elsewhere, have contracted better habits, and build very respectable nests of their own.

Indeed, we shall now soon begin to make progress in nest building, for the next group of birds, which

\* *Alcedo ispida*.



*dart* at their food with wide-gaping mouth and seize it on the wing, have among them many clever little architects. It is true our English kingfisher builds in holes on the river bank, lining her nest with fishes' bones, and the Nightjar (wrongly called the goat-sucker), with her wide-gaping mouth, lays her egg on the ground. But both these are lowly Darters, for the kingfisher sits on a bough close above the water, and pounces down upon the fish or water-insects; and the lonely nightjar, with her strange wailing cry, flits among the bushes in the twilight, or often even creeps after her prey.

Neither of these birds can compare in flight with the Swifts, as they dart upon the wing from some high pinnacle to collect a mouthful of insects, and come back to eat them, nor to the lovely little Humming Birds of America, which poise themselves so deftly on the wing, while their slender bill searches the long-tubed flowers for insects or seizes these as they pass. These living jewels of nature build beautiful and delicate nests of leaves and grass and spiders' webs interwoven like fairy cradles; while the swift makes a far stronger home of hair and feathers, grass and moss, glueing them together with saliva \* from his mouth, and fastening them under the eaves or on the top of some tall waterspout. It is easy to see why the swift chooses such lofty spots, for his slender weak toes are ill-fitted for standing on the ground, and he rises with great difficulty when once he has alighted there, but from a height he can drop easily on to the wing, and skim the air for his food.

\* The Indian and Chinese edible-nest Swiftlets (*Collocalia*), make their nests entirely of this saliva, and they are eaten by the natives.

Now the swift, which visits us only in summer to build his nest, when insects are plentiful, and spends the rest of his time in Africa, is a type of a whole army of birds, lovely, bright, and gay, with short weak feet, long wings, and a gaping mouth surrounded by bristly hairs, which swarm in hot countries where insects are to be found all the year round. Among these are the beautiful little Bee-eaters and Rollers of the East and Africa, which revel in insect food, and sometimes visit us in the summer, coming over to the south of Spain, or even, in the case of the rollers, as far north as Sweden ; while in South America the dull-coloured Puff-birds, the brilliant Jacamars with their metallic-looking feathers, the delicate little Todies, the bright green Motmots, and the lovely Humming-birds, swarm in countless numbers, hiding among the dense foliage, or darting in the bright sunshine after bee or butterfly, or other unwary insects.

But we must not pause too long among these smaller groups of birds, for the multitude of perching birds, which form nine-tenths of the whole bird kingdom, await us with their delicate nests and their happy family life. Ah ! now we are really coming to nature's feathered favourites, for what can be sweeter than the song of the nightingale, the skylark, or the thrush ? or more touching than the fact that the young ones learn from their father the loving notes ; that they, in their turn, may be able to woo and win some gentle mate to share their nests and bring up their young ones ? It is for this that they have gained that wonderful singing

instrument which they have deep down in their throat. For they do not produce their sounds as we do, just below the back of the mouth, but at the lower end of the windpipe, just where it divides into two branches, one going to each lung. There, where the rush of the air is strongest, is found a complicated apparatus, moved by a whole set of muscles, upon which the little fellow plays, and seems never to be exhausted, so much air has he in all parts of his body. And as the song pours through the windpipe there again he can help to give it its soft mellow tones, for while in hoarse-crying birds, like the sea birds and the waders, this tube is long and stiff, in the sweet singing birds it is short, and the bony rings composing it are thin and far apart, with soft delicate membrane between them, which can be shortened or lengthened to modulate the tones. And so we hear them in the springtime pouring forth their full tide of song to tempt a young wife to come and help them to build a nest ; or, in the full pleasure of success, trilling out their delight in the warm bright sunshine, and calling on all the world to be as happy as they.

Yet it is not by any means all the perching birds which have this wonderful gift of song. Even among our own birds, the jay, the crow, the raven, and others, use their musical instrument for talking in a way that is no doubt useful to them, but scarcely pleasant to hear ; and in America there is a whole group of songless perching birds—the bright coloured chatterers, the fly-catching tyrant-birds, the American ant-thrushes, which have not even developed a true singing instrument in their throat, and

only utter shrill or bell-like cries. Yet they all build nests and cherish their helpless young ones ; and so large and varied is the group of perching birds, whether in the Old or New World, that they fill all the stray nooks and corners of bird-life, often imitating the habits of the other smaller groups so as to get at food of all kinds. Thus, while the Finches with their delicate matted nests, the Warblers, and a large number of the smaller birds, lead a true tree and bush life, feeding on fruits and insects, the Thrushes, Blackbirds, Crows, Redbreasts, and Larks are *ground-feeders*, which, though they do not scratch with their feet like the partridges, turn up the ground with their bills and pick out the worms and grubs.

For this reason the Song-thrushes love to build their nest of twigs and moss lined with soft wood chips, in some thick hedge near to a meadow or garden, where they can drop down and pull up the unfortunate worms before they have gone home underground after their nightly rambles, or pounce upon unwary snails, and, taking them in their beak, crack the shell upon a stone, and carry off the dainty morsel to their brood ; while the Lark, with her long hind toe, so well fitted for walking, hides her nest in a furrow on the ground ; and the greedy cunning Magpie, feeding, as she often does, on young animals, seems to fear the same fate for her own brood, and builds a large egg-shaped dome of thorny branches, with the thorns sticking out on all sides, and lined with mud and soft roots, leaving only a small hole for a door. Lastly, the sagacious Rooks, though ground-feeders, build strong homes which last from year to year, in the top of the high elms, and



set out in companies in the early morning to their feeding grounds.

Fig. 45.



Nest of the Common Wren.\*

Then, as there are ground-feeders among the

\* *Troglodytes parvulus*.

perchers, so, too, there are *climbers*, for the Creepers, the Wryneck, and the Nuthatch, run up and down the trees, feeding on insects and nuts, which the nuthatch breaks so cleverly with his beak; and we might almost fancy them to be first cousins to the woodpeckers, if it were not for their three toes in front and long claw behind, and their short thick beak and tail. Even the little Wren, with her cocked-up tail, imitates the climbers as she creeps through the hedges and under-wood, though she is a true perching bird, and builds one of the most perfect of nests of moss and grass, woven into the shape of a ball, with a tiny hole for a door. Then, to match the *darting* birds, we have the Swallow and the Fly Catcher which follow insects on the wing, so that the swallow and swift were long confounded together, though the skeleton of the swallow shows that it belongs to perching birds. Again, the Shrike imitates the birds of prey, feeding on small mice, reptiles, and birds, and impaling them upon a sharp thorn while he tears them to pieces with his beak. Yet he is a true percher, singing as beautifully as many of the smaller birds, and he is even said to use his power of song to lure victims within reach. Lastly, and perhaps most curious of all, the little Dipper or Water-Ouzel, with his clear loud song, and his structure so like to the thrushes, has actually taken to the habits of water-birds, and dives into the depths of the river, running along upon the bottom and feeding on water-snails and water-insects.

All these we find among English birds; and if we had space to speak of other countries, we should find the same history there, for the more we study

bird-life the more we find that these Perchers are its highest types, and have learned to make the most of their kingdom. It is they who build the most perfect nests, from the rough strong basket-work of the crow or the magpie, to the wren's thickly-woven ball, or the finches' matted cups; while in America the Hang-nests weave their lovely pear-shaped homes, and suspend them like fruit from the tips of the branches; and in India and China the Tailor-birds actually sew leaves together with cotton fibre or cobweb threads, which they draw through with their slender bill and strengthen with saliva.

The smaller the bird and the more delicate its feet and bill, the more closely woven, as a rule, is its nest. Yet all are built with care; the mother bird, as a rule, choosing the position and laying the twigs, while the father helps her to collect the materials. So rapidly do these little creatures work, that among our smaller English birds the early morning sees the work begun, and by evening it is ended. Other birds are longer, according to the amount of material they have to collect; but all labour industriously till the

Fig. 46.



Nest of the Tailor-Bird \*  
of India or China.

\* *Orthotomus sutorius*.

cradle is finished, and then begins the laying, the sitting, the tender care of the mother for her little ones, and of the father for his wife and brood.

And indeed there is much need both of skill in nest building and of watchfulness for many a long day after, for if the perchers are the highest, they are not by any means the strongest of birds ; and while they feed on insects and smaller creatures, they have to guard their little ones with anxious care against the larger birds of prey which rule as masters in the higher regions of the air. It is on rocky pinnacles and in the clefts of inaccessible heights among the mountains that we must look for the nests of the Eagle, the Vulture, and the Falcon. Strong, powerful, and untiring in flight, they sail majestically high up in the air, not to sing a joyful song like the lark, but with piercing eye to search every corner for miles around, for animals of all sizes, from the dead ox or mule to the tiny living mouse or bird, which can serve for a meal.

It needs only a glance at them to see that they are strong destroyers, with their powerful wings, their sharp hooked beaks, their long toes with pointed claws, and their strong muscular thighs ; and because most men admire strength and power, we call such birds *noble*, though their nobility chiefly consists in loving their little ones, and asking neither pity nor shelter from others, as they themselves are pitiless in return. Those which we are apt to like the least, the carrion-feeding Vultures of hot countries, are really the most useful and harmless, for they feed chiefly on dead animals and clear the land of carrion ;



and for this reason neither their beak nor their claws are as strong as those of the fighting birds. But though they are grand in flight they are but repulsive-

Fig. 47.



The Eagle bringing food to its young.—(*From a coloured lithograph by Keulemann.*)

looking birds when compared with the lordly eagles. The beautiful Golden Eagle of Europe, with its dark

plumage and the golden sheen on its back and tail, is indeed a splendid object, as

“ He clasps the crag with hooked hands,  
Close to the sun in lonely lands,”

or still more, as he sweeps along with steady flight, circling round and glancing with searching eye over the plain beneath. Suddenly his attitude changes ; he closes his wings, and, head downwards, drops to earth slantingwise with a rushing noise, seizing in his claws the startled fawn as it dashes by at full speed, the frolicking rabbit darting into its hole, or the terrified bird upon whom his choice has fallen. Then, with a powerful stroke he rises up again, and is lost to sight as he soars aloft and regains the rocky peak where his eyrie is built and his children are clamouring for food.

So, too, the dexterous Falcon swoops upon his prey swift as an arrow, his pointed wings striking the air, and then closing at once upon his body, while his long rounded tail guides him in his flight. Who would think that such a powerful and bold robber could have anything in common with the soft feathered owl which sits blinking its large eyes in the hollow of the tree till the twilight falls ? And yet the Owl, with very little change in structure, has become as fitted to follow prey at night as the falcon is by day—

“ What time the preying owl, with sleepy wing,  
Sweeps o’er the cornfield, studious.”

The soft, round, broad wings, which would serve badly for striking a quarry from on high, are exactly fitted for gliding in the silence of the night, as, guided by wide open eye and ear, he skims over the fields

or round the stacks in the yard to pounce noiselessly upon the unwary mouse or to seize the flying beetles and bats. Then the sharp claws appear quickly from under the downy feathered feet, and clutch the smallest prey with needle-like precision ; and away the owl flies to his nest, so quietly that even the other animals close by are not alarmed, but in ignorant security remain till he comes to strike again.

And as the day and the night by land have their relentless freebooters, so the sea too has its eagle king ; for the Osprey, with its nest on a high rock, hovers over the open sea, and, dashing into the deep, returns with a large fish in its claws ; and, as it tears the flesh from under the glittering scales, reminds us that there is no spot on the earth in which some bird does not seek its prey.

We have now in very brief outline followed the feathery tribe from the flightless penguin to the boldly-soaring eagle, the king of the air. Those feathers which in the swimming bird are scarcely more than finely-divided scales, and in the ostrich mere loose nodding plumes, have become in the albatross, the vulture, and the soaring falcon, flying instruments of such power and strength that the earth and the water are as nothing to them compared with the free ocean of air ; while even the tiny graceful swallow flies for hundreds of miles to its winter home.

Indeed, we have here one of the great secrets of bird success ; for while most animals must roam within limited districts, and get their food there as best they can, thousands and tens of thousands of birds set off, when the colder weather makes food scarce in any

one region, and travel hundreds of miles to more genial climates, where insects are still to be found, and the trees are still covered with fruit and leaves. How strange it is to think that while we are making the best of our winter, the swallow has taken her unerring flight to Africa, the swans and cranes have long since made their southward journey, and myriads of small birds have gone in search of food and warmth, to return next spring as certainly to their old haunts, where they can breed in cool and comfortable quarters!

If we could only get the birds to tell us how they have learned the routes they take, and by what rules they are guided! One thing we know, that each kind of bird makes its nest in the coldest region which it visits, and where, at the time its young brood are ready, insect and other life is abundant; so that while the wild duck and goose, the woodcock, snipe, and field-fare, go to the far north to lay their eggs, and come to us in the sharper weather to feed when there is nothing but ice and snow in the home they have left, the swallow, the cuckoo, the swift, and the wheatear, on the other hand, visit us in the spring to build, and when autumn comes on take their flight to Africa and the East; and even many of the song-thrushes and robin-redbreasts which remain with us in England start off from Germany to warmer climates. Others, again, such as some of the Reed-warblers, the Stint, and the Ortolan Bunting, only make our island a house of call between the arctic regions where they breed in the summer when mosquitoes are swarming there, and the south where they winter after flying thousands of miles.



It would take too long to discuss here why and how they go, even if we knew it with certainty ; but it is most probable that their ancestors first learned the routes now taken when Europe and Africa had not so wide a sea between them, and we can see that it must be a great advantage to be able to travel from climate to climate, so as to find a plentiful table spread at all times of the year ; while they may return to the north to breed, not merely because there is food there, but also because in still earlier times, when the northern countries were much warmer than they are now, they doubtless lived there altogether, and, though now obliged to go south, have never lost the tradition of their old home.

Thus the birds, with their feathery covering and powerful wings, have left their early friends, the reptiles, far far behind. Taught by their many dangers, many experiences, and many joys, they have become warmhearted, quickwitted, timid or bold, ferocious or cunning, deliberate as the rook, or passionate as the falcon, according to the life they have to lead ; or, in the sweet tender emotions of the little song-birds, have learned to fill the world with love and brightness and song. If mere enjoyment were all that could be desired in life, where could we expect to find it better than in the light-hearted skylark as she rises in the early summer morning to trill forth her song of joy, or in the happy chuckle of the hen as her little ones gather around her.

Yet we cannot but feel that, happy as a bird's life may be, it still leaves something to be desired ; and that, with their small brain and their front

limbs entirely employed in flying, they cannot make the highest use of the world. The air they have conquered ; and among the woods and forests, over the wide sea, and above the lofty mountains, they lead a busy and happy existence, bringing flying creatures to their highest development, and showing how Life has left no space unfilled with her children. Yet, after all, it is upon the ground, where difficulties are many, conditions varied, and where there is so much to call for contrivance, adaptation, and intelligence, that we must look for the highest types of life ; and while we leave the joyous birds with regret, we must go back to the lower forms among the four-footed animals, in order to travel along the line of those that have conquered the earth and prepared the way for man himself.

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